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ORIGINAL RESEARCH

Predictive Value of the COPD Assessment Test Combined with Five-Repetition Sit-to-Stand Test for Impaired Exercise Tolerance in Primary Care COPD Patients: A Comparative Study with Cardiopulmonary Exercise Testing

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Purpose: This study aimed to determine the longitudinal trends of impaired exercise tolerance in patients with chronic obstructive pulmonary disease (COPD) and to evaluate the predictive value, agreement, and longitudinal stability of the COPD Assessment Test (CAT) combined with the the Five-Repetition Sit-to-Stand Test (5STS) in relation to cardiopulmonary exercise testing.

Patients and Methods: This exploratory, prospective, 12-month cohort study consecutively enrolled 100 patients with stable COPD who attended the outpatient clinic of the Department of Respiratory and Critical Care Medicine at China-Japan Friendship Hospital from January 2021 to October 2025. Impaired exercise tolerance group was defined as a predicted percentage of peak oxygen uptake (peak VO_{2pred}) < 85%, as measured by CPET. Patients were evaluated for Physical Fitness at baseline and 12 months using the following tools: modified Medical Research Council (mMRC) questionnaire, CAT score, 5STS, Hand Grip Strength (HGS), Timed Up and Go (TUG) test, and Quadriceps maximal voluntary contraction (QMVC).

Results: At baseline, 58% of COPD patients exhibited impaired exercise tolerance. A statistically significant difference ($P < 0.05$) was observed in CAT score and 5STS results between the impaired exercise tolerance group and the normal exercise tolerance group. The combined CAT score and 5STS demonstrated a sensitivity of 52.5%, a specificity of 92.7%, and an area under the receiver operating characteristic curve (AUC) of 0.759 (95% CI: 0.666–0.852, $P < 0.001$) for identifying impaired exercise tolerance, indicating that this combination is most effective for ruling in the impairment. Agreement analysis with peak VO_{2pred} demonstrated that the CAT score and 5STS showed fair agreement, with consistently moderate predictive value across all time points.

Conclusion: The combined application of the CAT score and the 5STS provides both screening and longitudinal monitoring capabilities, indicating potential for identifying patients with COPD at high risk of impaired exercise tolerance in primary care.

Keywords: COPD, exercise tolerance, cardiorespiratory function, primary care rehabilitation, CAT score, 5STS

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Introduction

Chronic Obstructive Pulmonary Disease (COPD) is an inflammatory lung condition that affects approximately 10% of the adult population and ranks as the third leading cause of death globally.[1] Patients with COPD experience symptoms such as dyspnea, diminished exercise capacity, anxiety, and depression, which collectively contribute to a substantially reduced quality of life.[2,3] According to the Global Strategy for the Diagnosis, Management, and Prevention of COPD by the Global Initiative for Chronic Obstructive Lung Disease (GOLD), pulmonary rehabilitation (PR) is recommended in clinically stable patients with the aim of improving dyspnea, exercise tolerance, quality of life, and reduce hospitalization frequency.[4]

Impaired exercise tolerance in patients with COPD is a multifactorial condition, resulting from the complex interplay among ventilatory dysfunction, peripheral muscle dysfunction, and cardiopulmonary system impairment. Contributing pathophysiological mechanisms include airflow limitation, dynamic lung hyperinflation, gas exchange abnormalities, systemic inflammation, dysfunction, and oxidative stress.[5] However, exercise tolerance itself serves as a key modifiable extrapulmonary feature in COPD management. Improving exercise capacity represents a core objective of PR, aiming to modify critical pathways linked to adverse clinical outcomes.[6] In PR practice, cardiopulmonary exercise testing (CPET) serves as the gold standard for assessing exercise tolerance, with a predicted percentage of peak oxygen uptake (peak VO_{2pred}) below 85% defined as impaired exercise tolerance,[7] thereby providing precise pathophysiological evidence. However, a major challenge in primary care practice is the lack of CPET equipment, which prevents the completion of cardiorespiratory fitness assessments. Commonly used alternative functional evaluation methods, such as the 6 minute walk test (6MWT) or the incremental shuttle walk test (ISWT), are often infeasible in community settings due to equipment and space constraints, highlighting the urgent need for simplified alternative methods to evaluate exercise tolerance.

The COPD Assessment Test (CAT) and the Five-Repetition Sit-to-Stand Test (5STS) can serve as simple clinical surrogate measures, reflecting the two key domains of "symptom burden" and "lower limb muscle function" respectively. The GOLD strategy document recommends the CAT score—an eight-item questionnaire evaluating cough, sputum, chest tightness, dyspnea, activity limitation, confidence, sleep, and energy. Previous studies have demonstrated that the CAT score is associated with peak oxygen uptake in CPET and the number of steps in the six-minute step test (6MST), indicating its utility as a tool for predicting exercise tolerance in COPD.[8,9] Moreover, the CAT score correlates with the severity of airflow limitation in COPD patients, with worsening health status measured by the CAT score corresponding to more severe airflow limitation, establishing it as a standardized instrument for assessing disease severity.[10] The CAT score is also critical for evaluating acute exacerbations and predicting future risk.[11] The Sit-to-Stand Test (STS) is a simple, equipment-free tool available in short (5–10 s), intermediate (30–60 s), and long duration versions (3 min). It correlates with 6-minute walk distance (6MWD), handgrip strength (HGS), quadriceps maximal voluntary contraction (QMVC), and St. George's Respiratory Questionnaire scores (SGRQ).[12,13] Previous studies have established that the 5STS is associated with exercise capacity assessments such as the 6MWT and the incremental shuttle walk test (ISWT).[14,15] As a standardized functional test evaluating lower limb muscle strength and balance, the 5STS is reliable, valid, and responsive in patients with COPD. It effectively predicts functional status, fall risk, and survival rates in this population and is suitable for use in most healthcare settings. The combination of the CAT score and the 5STS integrates multiple systems—including circulatory, respiratory, metabolic, and muscular—to capture key physiological determinants of peak oxygen uptake.

This study aims to address the knowledge gap that currently exists regarding the lack of a simple, widely applicable assessment tool with validated consistency and longitudinal stability, verified by CPET, for use in the population of patients with stable COPD. Using CPET as the the gold standard for assessing exercise tolerance, this study evaluates the predictive value, agreement, and longitudinal stability of the CAT score combined with the 5STS. The findings of this study will assist primary care physicians in identifying COPD patients at high risk of impaired exercise tolerance.

Therefore, this exploratory study aims to: a) assess the impairment status and 12-month longitudinal trends of exercise tolerance in 100 patients with stable COPD who have received clinically optimized treatment; b) evaluate the predictive value of the CAT score, 5STS, and their combination; c) apply the Kappa statistic to analyze the agreement of the CAT score and 5STS with the CPET gold standard at baseline and follow-up, as well as the diagnostic performance of the combination.

Materials and Methods

This was an exploratory, prospective, 12-month cohort study based on data from an existing clinical cohort (Registration ID: 2021–12M-1-049). The study consecutively enrolled 100 patients with stable COPD who attended the outpatient clinic of the Department of Respiratory and Critical Care Medicine at China-Japan Friendship Hospital from January 2021 to October 2025. This study followed the Helsinki Declaration guidelines and was approved by the Ethics Committee of the China-Japan Friendship Hospital (Ethical Review No. 2022-KY-141). The subjects provided informed consent before participation.

Participants

Patients with stable COPD diagnosed according to the Global initiative for GOLD guidelines.[4] Inclusion criteria included: (1) Patients with a confirmed diagnosis of COPD, established and graded according to the 2021 Global Initiative for COPD diagnostic and management guidelines, and exhibiting a post-bronchodilator FEV_1/FVC ratio <70% after exclusion of other relevant diseases.[16](2) Patients with no new acute exacerbation of COPD in the last 12 weeks, physical inability to stand up from a chair and sit back down without assistance, significant and unstable cardiovascular disease, any acute or chronic condition limiting the performance of a functional test (including psychiatric, neurological, orthopaedic or cognitive disorders), Non-eligible patients were excluded according to the absolute contraindications and relative contraindications in the Chinese Expert Consensus on Cardiopulmonary Exercise Testing to prevent the risk of exercise-induced adverse cardiovascular events and other risks.[17] The specific experimental flowchart is shown in Figure 1.

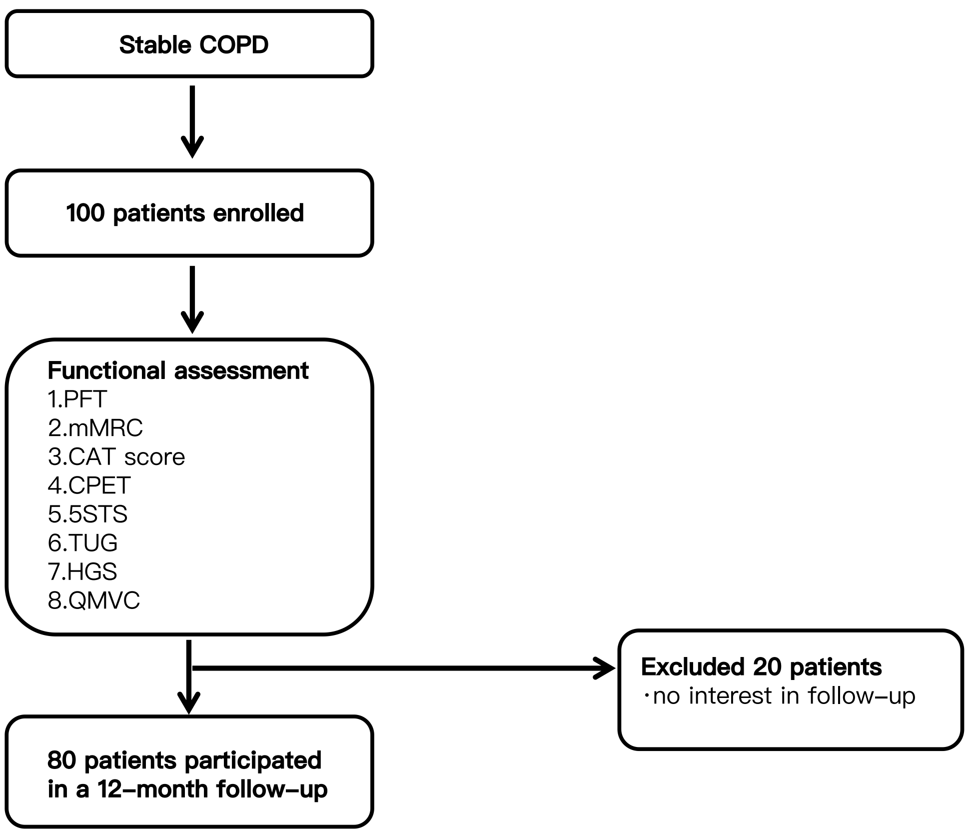

Figure 1 Flowchart of this study.

Abbreviations: PFT, Pulmonary Function Test; mMRC, Modified Medical Research Council; CAT, COPD Assessment Test; HGS, hand grip strength; 5STS, five-repetition sit-to-stand test; TUG, Timed Up and Go Test; CPET, cardiopulmonary exercise testing; QMVC, quadriceps maximal voluntary contraction.

Protocol

Patients were recruited from the outpatient clinic of the Department of Respiratory and Critical Care Medicine and followed up accordingly. After obtaining informed consent and confirming eligibility against the inclusion criteria, anthropometric and clinical data were collected at the initial visit (V0), including the modified Medical Research Council (mMRC) questionnaire, CAT score, CPET, 5STS, Timed Up and Go Test (TUG), HGS, and QMVC. Researchers conducted monthly remote follow-ups (via phone/video consultations and SMS) to inquire about patients' oxygen saturation levels and dyspnea severity, ensuring that patients remained in a stable state of COPD. Throughout the follow-up period, patients did not participate in other clinical studies, and researchers did not intervene in their daily lives. An annual follow-up was conducted at 12 months, during which the same set of anthropometric and clinical data was collected (V1). All baseline and follow-up assessments in this study were performed by two experienced physical therapists, with each session lasting 45 to 60 minutes. To evaluate inter-rater reliability, 20% of the participants were randomly selected for independent repeated assessments of the CAT score and 5STS. Intraclass correlation coefficient analysis demonstrated excellent reliability for both tests. In the longitudinal data collection, each participant was assigned to a fixed therapist for all assessments to ensure comparability of follow-up data.

Sample Size Calculation

The sample size was calculated a priori using PASS software (version 2025), based on the primary aim of evaluating the correlation between the CAT score/5STS and CPET-measured peak VO_{2pred}. Using the more conservative correlation coefficient for the CAT score ($r = 0.337$, derived from pilot data) and setting a two-sided alpha of 0.05 with 80% power, 71 participants were required. To compensate for an estimated 20% attrition rate over the 12-month follow-up, at least 89 patients with stable COPD were recruited at baseline.

Missing Data Handling and Sensitivity Analysis

The primary statistical analysis of this study was based on 80 patients who completed the 12 - month follow-up with complete data. To evaluate the robustness of the conclusions regarding the 20 patients with partially missing follow - up data among the 100 initially enrolled, sensitivity analyses were performed. First, baseline characteristics (eg, age, sex, the CAT score) were compared between the 20 non - completers and the 80 completers. Multiple imputation was then applied to impute the missing values, and the main outcomes were compared between the 80 completers and the imputed full sample of 100 patients. Additional methodological details are provided in Supplementary Material.

Procedures and Data Collection

Clinical Data

Data on patient demographics such as age, gender, weight, height, and clinical respiratory markers such as post-bronchodilator forced expiratory volume in one second (FEV_1), forced vital capacity (FVC) and forced expiratory volume in the first second as a percentage of the estimated value (FEV_{1pred}), were collected during the inclusion visit.

Questionnaire and Scales

mMRC dyspnea scale

mMRC dyspnea scale was used to determine the severity of the patient's self-imposed dyspnea based on a 4-point scale, where higher scores indicated severe dyspnea.[18] The minimal clinically important difference (MCID) was defined as a decrease of ≥1 grade in the mMRC dyspnea scale.[19]

CAT Score

CAT score was used for supplemental spirometry and assessment of risk with a total score of 40 grouped as follows: 0 −10, 11–20, 21–30, and 31–40 representing mild, moderate, severe, and very severe clinical effects, respectively. A score of 20 or more indicates that the patient should be actively involved in clinical care.[20] The MCID was defined as a decrease of ≥2 points in the CAT score.[21] CAT score ≥10 points was used to define the threshold for an increased symptom burden.[22]

Physical Fitness Assessment

CPET

CPET was profromed using the German Yeager masterscreen cardiopulmonary exercise testing system . The room temperature and humidity for CPET were adjusted to 20~25 °C and 45%~60%, respectively. The environment, volume, and gas were calibrated every day to ensure the accuracy of the CPET test. No medications were stopped before completing CPET. Smoking and coffee were prohibited during CPET. Also, no strenuous exercise was done before the test. Preparation before CPET involves patients wearing comfortable clothes and shoes. A symptom-limited load test was used to determine the continuous incremental program (RAMP program), taking into account the patient's age, gender, body size, exercise history, and clinical history. The selected power increment was appropriate, and the patient could maintain the CPET test for 8 to 12 min. Respiratory cycle data, such as heart rate, blood pressure, oxygen saturation, resting ECG, VO_2, VCO_2, etc, were collected during the 3-minute resting period. The patient warmed up with 10 W or 15 W for 3 minutes while keeping the rotation speed at 55–65 rpm. A metronome was used to keep the rotation speed. The test was completed with the set incremental loading program while observing the patient's electrocardiogram, heart rate, blood pressure, oxygen saturation, respiratory metabolism indexes, and conscious exertion.[17] Impaired exercise tolerance was defined as a predicted percentage of peak oxygen uptake (peak VO_{2pred})< 85% as measured by CPET.[23,24] This indicator assesses aerobic exercise capacity and cardiopulmonary reserve, reflecting adverse outcomes (such as acute exacerbations, hospitalization, and mortality) in patients with COPD.

5STS

5STS is widely used to measure muscle strength around the lower extremities. Briefly, a chair with a height of 47 cm from the seat plane to the floor was selected and fixed against a wall following the standard test requirements. The patient sat on the chair with their feet flat on the floor, arms and wrists crossed, and held in front of the chest. The patient was signaled "start" and timed to complete a full standing and sitting position, touching the seat as a movement unit. The "stand-up-sit-down" maneuver was repeated five times as fast as possible without using the arms. The completion time of the test was recorded.[25] The MCID was defined as a decrease of ≥1.7s in the 5STS.[15] Based on the 2019 AWGS Consensus, a 5STS≥12s was classified as functional decline.[26]

TUG

TUG is used to assess dynamic balance, mobility, and fall risk in older adults. Briefly, a seat with a height of 45cm and armrests of 20 cm was selected according to standard test requirements. The patient was required to complete standing up, walking 3 meters, turning 180 degrees around a conical bucket, walking 3 meters, and leaning back in the seat. The time to complete the test was recorded (leave the back of the chair and sit down again (recline to the back of the chair).[27] The MCID was defined as a decrease of ≥1.4s in the TUG.[28]

HGS

HGS was measured using the grip strength meter as follows: The subject′s body was straight, feet apart, two arms down, and grip strength was applied to avoid touching the body or clothes. The pointer faced outward while adjusting the distance according to the size of the hand to make the 2nd joint of the index finger close to the right angle. The reading of the grip strength meter was recorded twice after the maximum force was exerted (5–10 s), and the maximum value was taken for further analysis.

QMVC

Before the test, participants were inquired about any history of leg trauma; affirmative responses were noted. Seated upright on a firm chair, the subject was fitted with the apparatus. Two straps were routed through the sensor. The strap incorporating the sensing ball was affixed to the measurement site via its buckle. The complementary strap was anchored to a chair leg. To preclude slippage, strap lengths were meticulously adjusted. Participants subsequently performed a maximal pull on the strap, and the peak value indicated on the sensor display was documented.

Statistical Analysis

SPSS 26.0 software was used for all statistical analysis. Baseline differences between groups, Impaired exercise tolerance was defined as a peak VO_{2pred} < 85% as measured by CPET, were assessed as follows: Categorical variables were analyzed using the Chi-square test. Normally distributed continuous data are presented as Mean±SD and were compared between groups using the independent-samples *t*-test. Non-normally distributed continuous data are expressed as median (P25, P75) and were compared using the Mann–Whitney *U*-test. The predictive value of the CAT score and the 5 STS test for impaired exercise tolerance was evaluated using Receiver Operating Characteristic (ROC) curve analysis. A two-sided P-value of less than 0.05 was considered statistically significant.

A Sankey diagram illustrated changes in endurance impairment classification between baseline (T0) and 12 months (T1). Changes in test scores from T0 to T1 were analyzed with independent-samples t-tests or Mann–Whitney *U*-tests based on data distribution, and the Chi-square test compared the proportions achieving the MCID.

The agreement between the classification based on peak VO_{2pred} < 85% consumption and the classification of impaired exercise tolerance derived from CAT score and 5STS was assessed using the unweighted Kappa statistic. The results were interpreted according to the criteria of Landis and Koch (1977): <0.20, slight agreement; 0.21–0.40, fair agreement; 0.41–0.60, moderate agreement; 0.61–0.80, substantial agreement; and >0.80, almost perfect agreement.[29]

Using the peak VO_{2pred} classification as the gold standard, PPV (PPV = true positives / [true positives + false positives]) and NPV (NPV = true negatives / [true negatives + false negatives]) were calculated. A cut-off value of peak VO_{2pred} <85% was selected to define the at-risk population based on clinical relevance, aiming to identify individuals with impaired exercise tolerance . The predictive values were interpreted according to Fleiss (2013) as follows: <0.60, low predictive value; 0.60–0.79, moderate predictive value; and >0.80, high predictive value.[30]

Results

Comparison of Pulmonary Function test, mMRC Dyspnea Score, CAT Score, CPET, and Physical Fitness Indicators Between Patients with Normal and Impaired Exercise Tolerance

Table 1 presents the baseline characteristics of the participants. Among the 100 included subjects, 87% (87/100) were male, with a mean age of 63.2 ± 10.1 years and $FEV_{1\%pred}$ of 76.7 ± 24.8. The prevalence of impaired exercise tolerance at T0 was 58%.

At T0, the group with impaired exercise tolerance demonstrated a higher proportion of males, a greater smoking index (SI), and elevated CAT scores. Furthermore, this group showed significantly poorer results in the following parameters: the ratio of forced expiratory volume in 1 second to forced vital capacity (FEV_1/FVC), $FEV_{1\%pred}$, percent predicted peak expiratory flow (PEF%pred), percent predicted forced expiratory flow at 50% of FVC (MEF $50_{\%pred}$), percent predicted

Table 1 Comparison of Pulmonary Function test, mMRC Dyspnea Score, CAT Score, CPET, and Physical Fitness Indicators Between Patients with Normal and Impaired Exercise Tolerance

Variable	ALL (n = 100)	Peak $VO_{2\%pred}$≥85 (n = 42)	Peak $VO_{2\%pred}$<85 (n = 58)	P value
Male sex, n (%)	87 (87%)	37 (77%)	50 (89%)	0.005
Age (years), mean (SD)	63.2±10.1	64.7±9.6	62.2±10.4	0.234
Height (cm)	170.0 (163.0, 175.0)	169.5 (161.0, 177.5)	170.0 (164.0, 175.0)	0.604
Weight (kg)	70.4 (62.1, 81.0)	73.0 (60.7, 82.2)	69.1 (63.0, 80.0)	0.472
BMI (kg/m^2)	24.4 (22.2, 26.9)	24.4 (22.3, 27.1)	24.4 (21.9, 26.6)	0.418
SI (pack-years)	16 (0, 40)	0 (0, 30)	26 (0, 40)	0.015

(*Continued*)

Table 1 (Continued).

Variable	ALL (n = 100)	Peak $VO_{2\%pred}$≥85 (n = 42)	Peak $VO_{2\%pred}$<85 (n = 58)	P value
Comorbidities, n (%)				
Cardiovascular disease	16 (16%)	5 (10%)	11 (21%0	0.143
Hypertension	24 (24%)	12 (25%)	12 (23%)	0.822
hyperlipemia	17 (17%)	8 (17%)	9 (17%)	0.932
Diabetes	10 (10%)	4 (8%)	6 (12%)	0.594
Post-bronchodilator spirometry				
FEV1/FVC (%)	63.0 (47.9, 68.2)	66.3 (60.9, 69.3)	61.0 (41.9, 67.3)	0.001
FEV1pred (%) mean (SD)	76.7±24.8	86.9±17.4	69.6±26.8	<0.001
PEF%pred (%)	93.2 (72.6, 10.2)	96.6 (85.3, 116.2)	88.4 (66.3, 107.8)	0.017
MEF50%pred (%)	36.3 (20.3, 49.5)	43.1 (31.7, 52.6)	28.7 (12.4, 43.9)	0.002
MEF25%pred (%)	26.2 (16.1, 34.5)	28.1 (21.6, 34.5)	22.4 (14.1, 44.4)	0.064
MMEF%pred (%)	33.2 (18.8, 46.1)	39.7 (27.2, 47.4)	26.7 (12.8, 45.1)	0.007
Physical Fitness				
METs	5.8 (4.8, 6.7)	6.5 (5.8, 7.3)	5.2 (4.5, 6.3)	<0.001
Peak VO_2/kg (mL/kg/min)	20.3 (16.7, 23.6)	22.9 (20.1, 25.6)	17.7 (15.7, 22.2)	<0.001
O2/HR (mL/beat)	11.0 (9.2, 13.4)	11.4 (9.5, 14.2)	10.8 (8.9, 12.4)	0.127
O2/HR % pred (%)	93.5 (81.3, 105.8)	102.0 (95.5, 121.0)	86.0 (77.0, 98.0)	<0.001
mMRC Dyspnea Score	1 (0, 1)	1 (0, 1)	1 (0, 1)	0.302
CAT score	9 (5, 13)	7 (4, 9)	11 (7, 15)	0.002
5STS (s)	9.1 (7.6, 11.0)	8.0 (7.2, 9.3)	9.4 (1, 12.3)	0.001
HGS (L, kg) mean (SD)	32.6±8.2	32.2±9.1	33.0±7.6	0.637
HGS (R k) mean (SD)	35.2±8.3	34.1±9.4	35.9±7.5	0.294
TUG (s) mean (SD)	6.9±1.4	6.9±1.4	6.9±1.4	0.995
QMVC (L, kg)	26.2 (21.0, 30.5)	24.7 (19.6, 31.3)	26.6 (21.6, 30.1)	0.506
QMVC (R, kg)	26.4 (20.6, 32.5)	26.6 (19.9, 35.2)	26.3 (20.9, 31.1)	0.828

Note: Data are mean±standard deviation (SD), median (P25, P75) and n (%).
Abbreviations: BMI, Body Mass Index; FEV1/FVC (%), Forced Expiratory Volume in the First Second as a Percentage of the Forced Vital Capacity; FEV_{1pred}, Forced Expiratory Volume in the First Second as a Percentage of the Estimated Value; PEF, Peak Expiratory Flow Rate; MEF 25, Flow Rate at 25% Forced Expiratory Vital Capacity; MEF 50, Flow Rate at 50% Forced Expiratory Vital Capacity; MMEF 75/25, Mid-term Forced Expiratory Flow Rate; VO2, Oxygen Consumption; METs, Metabolic Equivalents; mMRC Dyspnea Score, Modified Medical Research Council; CAT, COPD Assessment Test; 5STS, five-repetition sit-to-stand test; TUG, Timed Up and Go Test.

forced expiratory flow at 75% of FVC ($MEF75_{\%pred}$), percent predicted maximum mid-expiratory flow ($MMEF_{\%pred}$), metabolic equivalent of task (METs), peak oxygen uptake (Peak VO_2), percent predicted oxygen pulse ($O2/HR_{\%pred}$), and the5STS ($P < 0.05$) (Table 1).

Table 2 Predictive Value of CAT Score, 5STS, and Their Combination for Impaired Exercise Tolerance

Variable	AUC	95% CI	Sensitivity (%)	Specificity (%)	Cut-Off Value	P value
CAT score	0.680	0.574–0.785	0.576	0.829	11	0.002
5STS	0.699	0.597–0.801	0.627	0.732	9.14	0.001
CAT score+5STS	0.759	0.666–0.852	0.525	0.927	11+9.14	0.000

Abbreviations: CAT, COPD Assessment Test; 5STS, five-repetition sit-to-stand test; AUC, Area Under the Receiver Operating Characteristic Curve; 95% CIs, 95% confidence intervals.

Predictive Value of CAT Score, 5STS, and Their Combination for Impaired Exercise Tolerance

The optimal cut-off value of the CAT score for predicting impaired exercise tolerance was 11 points, yielding a sensitivity of 57.6%, a specificity of 82.9%, and an area under the receiver operating characteristic (ROC) curve (AUC) of 0.680 (95% CI: 0.574–0.785, $P < 0.05$). For the 5STS, the optimal cut-off was 9.14 seconds, with a sensitivity of 62.7%, a specificity of 73.2%, and an AUC of 0.699 (95% CI: 0.597–0.801, $P < 0.05$). The combination of the CAT score and the 5STS demonstrated a cut-off value of 0.602, with a sensitivity of 52.5%, a specificity of 92.7%, and a significantly higher AUC of 0.759 (95% CI: 0.666–0.852, $P < 0.001$). (Table 2) (Figure 2)

Changes in Test Scores from T0 to the T1

From T0 to T1, significant increases were observed in the impaired exercise tolerance group: the CAT score increased by 2 points and the 5STS time by 1.44 s, respectively. Furthermore, among patients with impaired exercise tolerance at T0, the numbers of patients reaching the minimal clinically important difference for the mMRC Dyspnea Score (≥1 grade), CAT score (≥2 points), and 5STS (≥1.7 seconds) were 15, 25, and 23, respectively, corresponding to proportions of 33.3%, 55.6%, and 51.1%. These results were statistically significant ($P < 0.05$) (Table 3).

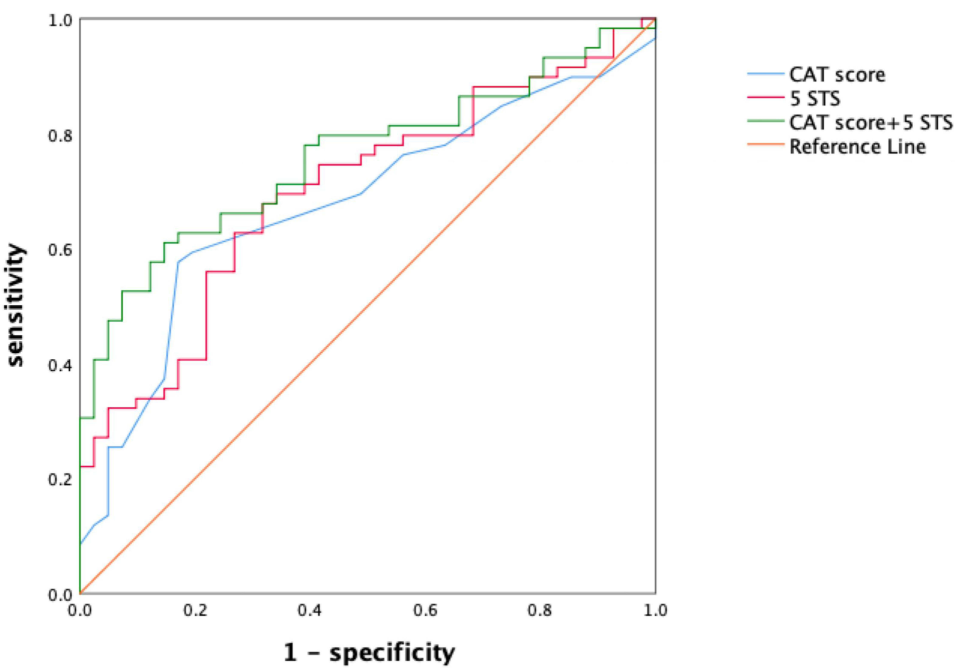

Figure 2 ROC curves for the CAT score, 5STS, and their combination in predicting impaired exercise tolerance among patients with stable COPD.
Abbreviations: CAT, COPD Assessment Test; 5STS, five-repetition sit-to-stand test; AUC, Area Under the Receiver Operating Characteristic Curve.

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Table 3 Changes in Test Scores from T0 to the T1

Variables	ALL (n=80)	T0 Peak VO2%pred≥85 (n=35)	T0 Peak VO2%pred<85 (n=45)	p value
ΔmMRC Dyspnea Score	0 (0, 0)	0 (−1, 0)	0 (0, 1)	0.016
ΔmMRC Dyspnea Score ≥1, n (%)	18 (22.5%)	3 (8.6%)	15 (33.3%)	0.009
ΔCAT score	0 (−2, 5)	−1 (−6, 2)	2 (−2, 6)	0.016
ΔCAT score≥2, n (%)	34 (42.5%)	9 (25.7%)	25 (55.6%)	0.007
Δ5STS (s)	1.01 (−0.48, 2.82)	0.25 (−1.19, 2.32)	1.44 (−0.09, 2.94)	0.042
Δ5STS≥1.7, n (%)	33 (41.3%)	10 (28.6%)	23 (51.1%)	0.042
ΔTUG (s)	−0.39 (−1.45, 0.71)	−0.12 (−1.22, 0.33)	−0.40 (−1.55, 1.17)	0.805
ΔTUG≥1.4, n (%)	13 (16.3%)	4 (11.4)%	9 (20.0%)	0.303
ΔHGS (L, kg)	−0.65 (−3.85, 2.00)	−0.90 (−2.50, 2.30)	−0.40 (−4.35, 2.00)	0.421
ΔHGS (R kg)	−1.60 (−4.18, 3.23)	−0.20 (−3.60, 3.00)	−2.40 (−4.90, 3.80)	0.322
ΔQMVC (L, kg)	−0.13 (−3.23, 5.26)	−0.20 (−3.35, 7.50)	0.00 (−3.15, 4.45)	0.648
ΔQMVC (R, kg)	−0.78 (−3.20, 4.85)	−0.75 (−2.90, 6.80)	−0.90 (−3.72, 4.53)	0.452

Abbreviations: mMRC Dyspnea Score, Modified Medical Research Council; CAT, COPD Assessment Test; 5STS, five-repetition sit-to-stand test; TUG, Timed Up and Go Test.

Distribution and Transitions of Patients by Exercise Tolerance Category (Peak $VO_{2\%pred}$ ≥85%, Peak $VO_{2\%pred}$ <85%) at T0 and T1

The prevalence of impaired exercise tolerance at T0 was 58% (58/100). Among patients with complete datasets at T1, the prevalence of impairment was 56.3% (45/80). Of the 42 patients with normal exercise tolerance at T0 and complete follow-up data, 61.90% (26/42) maintained normal exercise tolerance at T1, while 23.81% (10/42) progressed to impaired exercise tolerance; Additionally, 9.52% (4/42) were lost to follow-up, and 4.76% (2/42) declined to complete the CPET. Among the 58 patients with impaired exercise tolerance at T0 and complete data, 10.34% (6/58) showed improvement to normal exercise tolerance at T1, while 65.5% (38/58) remained impaired; Additionally, 17.24% (10/58) were lost to follow-up, and 6.90% (4/58) declined to complete the CPET. These longitudinal transitions are summarized in the Sankey diagram presented in Figure 3.

Predictive Value of the CAT Score and 5STS versus the Gold Standard for Exercise Tolerances at T0 and T1

Using a a peak $VO_{2\%pred}$ of <85% as the reference standard for defining impaired exercise tolerance and applying the corresponding cut-off values for the CAT score and 5STS, the results demonstrated stable kappa agreement and predictive values over the 12-month period. The CAT score showed fair agreement at both time points—T0 (kappa = 0.393, 95% CI: 0.222–0.564) and T1 (kappa = 0.328, 95% CI: 0.169–0.530)—and consistently demonstrated PPV and NPV. The 5STS also showed fair agreement at both time points—T0 (kappa = 0.371, 95% CI: 0.197–0.545) and T1 (kappa = 0.335, 95% CI: 0.137–0.533)—with consistently moderate PPV and NPV.(Table 4)

Discussion

The present study found that: (1) During the follow-up of COPD patients, 56–58% had impaired exercise tolerance, which remained largely stable over 12 months. Without structured PR, the majority of patients identified as having

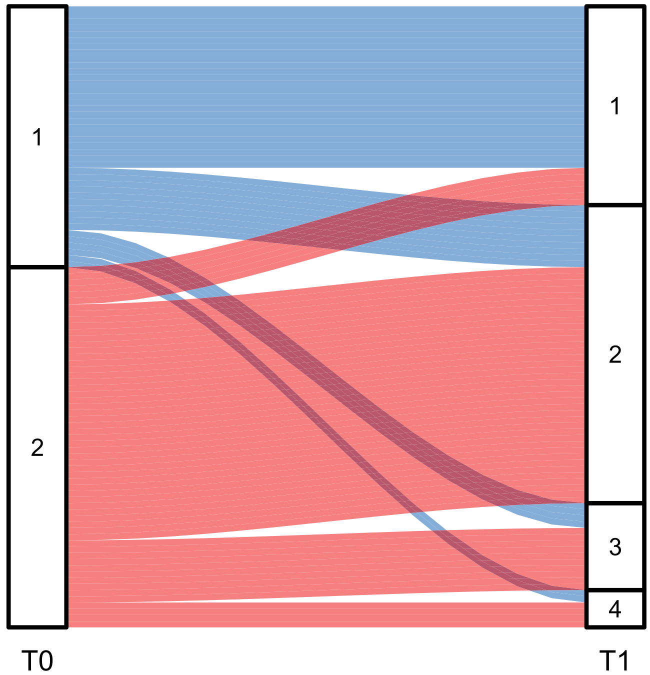

Figure 3 Distribution and Transitions of Patients by exercise tolerance Category at T0 and T1.
Notes: 1 normal exercise tolerance group; 2 impaired exercise tolerance group; 3 the lost-to-follow-up group; 4 CPET decliner group.

impaired exercise tolerance at baseline either maintained their status or experienced worsening. (2) The optimal cut-off values for predicting impaired exercise tolerance were 11 points for the CAT score (sensitivity 57.6%, specificity 82.9%, AUC 0.680) and 9.14 seconds for the 5STS (sensitivity 62.7%, specificity 73.2%, AUC 0.699). The combined prediction model yielded a sensitivity of 52.5%, specificity of 97.2%, and AUC of 0.759. These findings suggest that in primary care settings, physicians can use these thresholds—a CAT score ≥11 points and/or a 5STS time >9.14 s—to identify patients at risk of impaired exercise tolerance, warranting timely clinical interventions such as specialized assessment and PR. (3) As screening tools, the CAT score and 5STS demonstrated fair agreement, PPV, and NPV, all of which remained stable over the 12-month period.

Low physical activity levels have long been recognized as a common extrapulmonary manifestation in patients with COPD.[2,3,31] This study also identified impaired exercise tolerance as a prevalent finding, with a high prevalence of 56%–58%; furthermore, this impairment tended to remain stable over a 12-month period in the absence of formal rehabilitation. This highlights a critical issue: exercise tolerance does not improve spontaneously without structured PR. Importantly, reduced exercise tolerance is itself a treatable extrapulmonary trait of COPD. Existing evidence confirms

Table 4 Predictive Value of the CAT Score and 5STS versus the Gold Standard for Exercise Tolerance at T0 and T1

Variables	Time Point	Kappa (95% CI)	P value	PPV	NPV
CAT score	T0 (n=100)	0.393 (95% CI: 0.222–0.564)	P < 0.001	0.771**	0.673*
	T1 (n=80)	0.328 (95% CI: 0.169–0.530)	0.003	0.757**	0.679*
5STS	T0 (n=100)	0.371 (95% CI: 0.197–0.545)	P < 0.001	0.600**	0.617***
	T1 (n=80)	0.335 (95% CI: 0.137–0.533)	0.002	0.774**	0.776**

Notes: Complete data observations used for the comparisons (n=80). * High >0.80, ** Moderate 0.60–0.79, ***Low agreement <0.60.
Abbreviations: CAT, COPD Assessment Test; 5STS, five-repetition sit-to-stand test; PPV, positive predictive value; NPV, negative predictive value; 95% CIs, 95% confidence intervals.

that pulmonary rehabilitation, including endurance training (eg, cycling, walking) and interval training, can effectively improve physical capacity.[5,32,33] Previous studies in respiratory and geriatric medicine have assessed exercise tolerance using CPET, 6MWT, and the 2-minute step test (2MST).[34–36] Although these methods provide highly accurate and reliable results, their high cost, time-consuming nature, requirement for fixed facilities, and dependence on rigorously trained personnel limit their scalability and implementation in primary care settings. These constraints represent a significant barrier to effective chronic disease management in community-based healthcare systems in China.

In previous studies, 4-meter gait speed (4mGS) and the 6-minute step test (6MST) have been used, in comparison with CPET, to monitor exercise capacity in patients with COPD.[37,38] These tests require patients to walk at their usual walking speed and to repeatedly step onto a 20 cm high platform for 6 minutes, which may introduce shortcomings such as timing inaccuracies, fall risks, and potential joint injury. In primary care settings, there is a pressing need for simple, feasible, and portable assessment methods to rapidly identify COPD patients at high risk of impaired exercise tolerance. To date, no studies have directly compared multidimensional assessments—including the mMRC dyspnea scale, CAT score, 5STS, HGS, TUG, and QMVC—in terms of their ability to predict exercise tolerance as measured by CPET in COPD patients. Moreover, there is a lack of adequate evaluation of these tools using clinically interpretable agreement metrics and predictive accuracy. The present study addresses this gap by employing the above questionnaires and functional assessments, combined with statistical methods such as joint prediction, kappa statistics, PPV, and NPV, in comparison with the gold-standard CPET for assessing exercise tolerance. Our findings provide a simpler and more practical tool for early screening and stable monitoring of exercise tolerance impairment in COPD patients in primary care settings.

The CAT score is a validated instrument for evaluating and monitoring health status in patients with COPD and has been incorporated into the GOLD guidelines' combined assessment framework.[21] This score serves as an important auxiliary tool for predicting health status, exacerbation risk, depressive symptoms, and mortality in COPD patients.[22] The CAT score ranges from 0 to 40, with an increase of ≥2 points representing the MCID, indicating clinically meaningful deterioration in health status. This study found that the CAT score was negatively correlated with the Peak $VO_{2\%pred}$ an indicator reflecting exercise tolerance. Furthermore, during the 12-month follow-up period, a significantly higher proportion of patients with impaired exercise tolerance demonstrated an increase in CAT scores of ≥2 points, reaching the MCID, was 25 cases (55.6%), which was also significantly higher. This suggests that the CAT score exhibits a synchronous trend with impaired exercise tolerance in patients, both at baseline and during longitudinal follow-up. Previous studies have confirmed good consistency between different versions of sit-to-stand test protocols, validating their effectiveness in distinguishing patients with low versus preserved exercise capacity.[39] The 5STS requires participants to complete five repetitions of standing up from a seated position to full standing as quickly as possible, with the time (in seconds) recorded by a clinician or physical therapist. As a practical functional outcome measure, the 5STS demonstrates excellent reliability, validity, and responsiveness in COPD patients. This test effectively identifies dyspnea severity, quantifies health status, and serves as a predictor of severe exacerbations, increased hospitalization rates, and elevated mortality in this population.[13,14,40–43] In this study, the 5STS was validated using cardiopulmonary exercise testing—the gold standard for assessing exercise tolerance—as the reference. The results revealed that lower exercise tolerance was associated with longer 5STS completion times, and patients with impaired exercise tolerance exhibited significantly prolonged 5STS times, with a higher proportion (23 cases, 51.1%) reaching the MCID during the 12-month follow-up. This indicates that the 5STS aligns with trends in exercise tolerance impairment in both baseline and longitudinal follow-up assessments. During the observation period, despite potential changes in patient status over time, reliability and validity analyses indicated that both simple tools maintained mild agreement (Kappa coefficients of 0.32 at baselineT0 and 0.35 at follow-upT1) and moderate predictive value with the gold standard for exercise tolerance across different time points. The CAT score and 5STS are more suitable as tools for large-scale preliminary screening or long-term follow-up monitoring in primary care to identify COPD patients at high risk of impaired exercise tolerance; however, they are not suitable for risk stratification or diagnosis.

In this study, a combined prediction model utilizing the CAT score (a patient-reported outcome) and the 5STS (an objective functional indicator) demonstrated a specificity of 92.7%. This suggests that in primary care settings where

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CPET is not feasible, the combined application of the CAT score and 5STS can serve as a screening tool. A positive result, defined as a CAT score >11 and a 5STS time >9.14 seconds, indicates a 92.7% likelihood of impaired exercise tolerance, warranting further assessment or referral for PR and prioritizing the allocation of medical resources. However, the sensitivity of the model was only 52.5%, limiting its ability to identify symptomatic patients with a negative prediction, potentially leading to missed diagnoses of some COPD patients with actual exercise tolerance impairment. Nonetheless, as the model requires no specialized equipment, it can serve as an efficient "triage tool" in resource-limited settings. It is suitable for screening and longitudinally monitoring COPD patients at high risk of impaired exercise tolerance, offering high accessibility, convenience, rapid operation, simplicity, good acceptance, and safety in primary care settings. This enables early triage and optimizes patient management, highlighting the public health value and clinical utility of this study.

However, this study has several limitations. First, the moderate sample size, single-center design, male - dominated cohort (gender imbalance), and lack of adjustment for confounders may introduce selection bias and limit the generalizability of the findings, particularly in extrapolating the results to screening for impaired exercise tolerance in female COPD patients. Second, as a patient - reported outcome, the interpretation and reporting of symptoms in the CAT score may be influenced by patients educational levels. Moreover, the 5STS requires patients to perform rapid movements, which may be difficult for elderly individuals or those with comorbid musculoskeletal conditions (eg, osteoarthritis, osteoporosis), potentially leading to under - detection of some high - risk populations. Finally, the sensitivity of the combined prediction model in this study was only 52.5%, which may result in missed diagnosis of some patients with actual exercise tolerance impairment. Future research should include multi - center validation and the enrollment of a broader population (especially women) to further explore potential sex - and age - related differences and improve the generalizability of the results. Additionally, the impact of comorbid musculoskeletal diseases in COPD (such as osteoarthritis and osteoporosis) on the feasibility and interpretation of functional tests should be fully considered. More predictive factors should also be incorporated to enhance the sensitivity of the model. Finally, a standardized referral pathway should be established, covering initial assessment, result interpretation, PR referral, and long - term monitoring, thereby forming a clinical decision - support process based on simple tools and promoting the practical translation of research findings into primary care practice.

Conclusion

This study is the first to delineate the 12-month trajectory of exercise tolerance in patients with stable COPD and to validate the CAT score and the 5STS as practical tools for screening and longitudinally monitoring high-risk COPD patients with impaired exercise tolerance in resource-limited primary care settings.

Data Sharing Statement

Data for this study are not publicly available.

Ethics Approval and Consent to Participate

Ethics approval was obtained from the Ethics Committee of the China-Japan Friendship Hospital (Ethical Review No. 2022-KY-141). All participants provided written informed consent.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors disclose no conflicts of interest in this work.

References

1. Agusti A, Singh D, Faner R. Treatment of chronic obstructive pulmonary disease: current pipeline and new opportunities. *Nat Rev Drug Discov*. 2025. doi:10.1038/s41573-025-01290-6
2. Vogelmeier CF, Román-Rodríguez M, Singh D, et al. Goals of COPD treatment: focus on symptoms and exacerbations. *Respir Med*. 2020;166:105938. doi:10.1016/j.rmed.2020.105938
3. Mjid M, Snène H, Hedhli A, et al. COPD patients' body composition and its impact on lung function. *Tunis Med*. 2021;99(2):285–290.
4. Agustí A, Celli BR, Criner GJ, et al. Global initiative for chronic obstructive lung disease 2023 report: GOLD executive summary. *Eur Respir J*. 2023;61(4):2300239. doi:10.1183/13993003.00239-2023
5. Spruit MA, Singh SJ, Garvey C, et al. An official American Thoracic Society/European Respiratory Society statement: key concepts and advances in pulmonary rehabilitation. *Am J Respir Crit Care Med*. 2013;188(8):e13–64. Erratum in: Am J Respir Crit Care Med. 2014 Jun 15;189(12):1570. doi:10.1164/rccm.201309-1634ST
6. Cardoso J, Ferreira AJ, Guimarães M, et al. Treatable traits in COPD - A proposed approach. *Int J Chron Obstruct Pulmon Dis*. 2021;16:3167–3182. doi:10.2147/COPD.S330817
7. Dores H, Mendes M, Abreu A, et al. Cardiopulmonary exercise testing in clinical practice: principles, applications, and basic interpretation. *Rev Port Cardiol*. 2024;43(9):525–536. English, Portuguese. doi:10.1016/j.repc.2024.01.005
8. Pisi R, Aiello M, Calzetta L, et al. The COPD assessment test and the modified medical research council scale are not equivalent when related to the maximal exercise capacity in COPD patients. *Pulmonology*. 2023;29(3):194–199. doi:10.1016/j.pulmoe.2021.06.001
9. Dourado IM, Santos PB, Goulart CL, et al. Is the six-minute step test able to reflect the severity and symptoms based on cat score? *Heart Lung*. 2023;58:28–33. doi:10.1016/j.hrtlng.2022.10.010
10. Ghobadi H, Ahari SS, Kameli A, et al. The relationship between COPD Assessment Test (CAT) scores and severity of airflow obstruction in stable COPD patients. *Tanaffos*. 2012;11(2):22–26. PMID: 25191410.
11. Gil HI, Zo S, Jones PW, et al. Clinical characteristics of COPD patients according to COPD assessment test (CAT) score level: cross-sectional study. *Int J Chron Obstruct Pulmon Dis*. 2021;16:1509–1517. doi:10.2147/COPD.S297089
12. Vaidya T, Chambellan A, de Bisschop C. Sit-to-stand tests for COPD: a literature review. *Respir Med*. 2017;128:70–77. doi:10.1016/j.rmed.2017.05.003
13. Kakavas S, Papanikolaou A, Kompogiorgas S, et al. The correlation of sit-to-stand tests with COPD assessment test and GOLD staging classification. *COPD*. 2020;17(6):655–661. doi:10.1080/15412555.2020.1825661
14. Bernabéu-Mora R, Oliveira-Sousa SL, Medina-Mirapeix F, et al. Identifying COPD patients with poor health status and low exercise tolerance through the five-repetition sit-to-stand test and modified Medical Research Council Dyspnea Score. *Eur J Intern Med*. 2024;125:51–56. doi:10.1016/j.ejim.2024.03.032
15. Jones SE, Kon SS, Canavan JL, et al. The five-repetition sit-to-stand test as a functional outcome measure in COPD. *Thorax*. 2013;68(11):1015–1020. doi:10.1136/thoraxjnl-2013-203576
16. Chronic Obstructive Pulmonary Disease Group of Chinese Thoracic Society; Chronic Obstructive Pulmonary Disease Committee of Chinese Association of Chest Physician. Guidelines for the diagnosis and management of chronic obstructive pulmonary disease (revised version 2021), *Zhonghua Jie He He Hu Xi Za Zhi*. 2021;44(3):170–205. Chinese. doi:10.3760/cma.j.cn112147-20210109-00031
17. Balady GJ, Arena R, Sietsema K, et al. Clinician's Guide to cardiopulmonary exercise testing in adults: a scientific statement from the American Heart Association. *Circulation*. 2010;122(2):191–225. doi:10.1161/CIR.0b013e3181e52e69
18. Sunjaya A, Poulos L, Reddel H, et al. Qualitative validation of the modified Medical Research Council (mMRC) dyspnoea scale as a patient-reported measure of breathlessness severity. *Respir Med*. 2022;203:106984. doi:10.1016/j.rmed.2022.106984
19. Bondarenko J, Dal Corso S, Dillon MP, et al. Clinically important changes and adverse events with centre-based or home-based pulmonary rehabilitation in chronic respiratory disease: a systematic review and meta-analysis. *Chron Respir Dis*. 2024;21:14799731241277808. doi:10.1177/14799731241277808
20. Kon SS, Canavan JL, Jones SE, et al. Minimum clinically important difference for the COPD Assessment Test: a prospective analysis. *Lancet Respir Med*. 2014;2(3):195–203. doi:10.1016/S2213-2600(14)70001-3
21. Liu D, Song Q, Zeng Y, et al. The clinical characteristics and outcomes in non-frequent exacerbation patients with chronic obstructive pulmonary disease in the Chinese population. *Int J Chron Obstruct Pulmon Dis*. 2023;18:1741–1751. doi:10.2147/COPD.S417566.)
22. Vaezi A, Mirsaeidi M. Proposing the potential of utilizing the CAT score for early detection of COPD in asymptomatic patients, shifting towards a patient-centered approach: a review. *Medicine*. 2024;103(15):e37715. doi:10.1097/MD.0000000000037715
23. Chinese Society of Cardiology, Chinese Medical Association; Professional Committee of Cardiopulmonary Prevention and Rehabilitation of Chinese Rehabilitation Medical Association; Editorial Board of Chinese Journal of Cardiology. Chinese expert consensus on standardized clinical application of cardiopulmonary exercise testing, *Zhonghua Xin Xue Guan Bing Za Zhi*. 2022;50(10):973–986. Chinese. doi:10.3760/cma.j.cn112148-20220316-00180

24. Herdy AH, Ritt LE, Stein R, et al. Cardiopulmonary exercise test: background, applicability and interpretation. *Arq Bras Cardiol*. 2016;107(5):467–481. doi:10.5935/abc.20160171
25. Zanini A, Crisafulli E, D'Andria M, et al. Minimum clinically important difference in 30-s sit-to-stand test after pulmonary rehabilitation in subjects with COPD. *Respir Care*. 2019;64(10):1261–1269. doi:10.4187/respcare.06694
26. Chen LK, Woo J, Assantachai P, et al. Asian working group for sarcopenia: 2019 consensus update on sarcopenia diagnosis and treatment. *J Am Med Dir Assoc*. 2020;21(3):300–307.e2. doi:10.1016/j.jamda.2019.12.012
27. Albarrati AM, Gale NS, Munnery MM, et al. The timed up and go test predicts frailty in patients with COPD. *NPJ Prim Care Respir Med*. 2022;32(1):24. doi:10.1038/s41533-022-00287-7
28. Mesquita R, Wilke S, Smid DE, et al. Measurement properties of the timed up & go test in patients with COPD. *Chron Respir Dis*. 2016;13(4):344–352. doi:10.1177/1479972316647178
29. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33(1):159–174. doi:10.2307/2529310)
30. Fleiss JL, Levin B, Cho Paik M. *Statistical Methods for Rates and Proportions*. Third Edition. *3rd ed* ed. Wiley-Blackwell; 2013:461. doi:10.1002/0471445428
31. Kahnert K, Jörres RA, Behr J, Welte T. The diagnosis and treatment of COPD and its comorbidities. *Dtsch Arztebl Int*. 2023;120(25):434–444. doi:10.3238/arztebl.m2023.027
32. Troosters T, Janssens W, Demeyer H, et al. Pulmonary rehabilitation and physical interventions. *Eur Respir Rev*. 2023;32(168):220222. doi:10.1183/16000617.0222-2022
33. Moy ML. Maintenance pulmonary rehabilitation: an update and future directions. *Respir Care*. 2024;69(6):724–739. doi:10.4187/respcare.11609.)
34. Berlanga LA, Matos-Duarte M, Abdalla P, et al. Validity of the two-minute step test for healthy older adults. *Geriatr Nurs*. 2023;51:415–421. doi:10.1016/j.gerinurse.2023.04.009
35. Bohannon RW, Crouch RH. Two-minute step test of exercise capacity: systematic review of procedures, performance, and clinimetric properties. *J Geriatr Phys Ther*. 2019;42(2):105–112. doi:10.1519/JPT.0000000000000164
36. Kuz U, Maliuvanchuk S, Herych R, et al. Efficacy and safety of physical therapy in patients with stage III COPD during ambulatory rehabilitation. *J Med Life*. 2023;16(12):1769–1775. doi:10.25122/jml-2023-0237
37. Karcıoğlu O, Sarınç Ulaşlı S, Demir AU. A basic tool to determine exercise capacity in COPD: 4-meter gait speed. *Tuberk Toraks*. 2022;70(1):54–62. English. doi:10.5578/tt.20229907
38. Grosbois JM, Riquier C, Chehere B, et al. Six-minute stepper test: a valid clinical exercise tolerance test for COPD patients. *Int J Chron Obstruct Pulmon Dis*. 2016;11:657–663. doi:10.2147/COPD.S98635
39. Morita AA, Bisca GW, Machado FVC, et al. Best protocol for the sit-to-stand test in subjects with COPD. *Respir Care*. 2018;63(8):1040–1049. doi:10.4187/respcare.05100
40. Farley C, Phillips SM, Smith-Turchyn J, et al. Measurement properties of the sit-to-stand test in people with chronic obstructive pulmonary disease: Protocol for a systematic review and meta-analysis using the COSMIN guidelines. *PLoS One*. 2024;19(12):e0316451. doi:10.1371/journal.pone.0316451
41. Medina-Mirapeix F, Bernabeu-Mora R, Valera-Novella E, et al. The five-repetition sit-to-stand test is a predictive factor of severe exacerbations in COPD. *Ther Adv Chronic Dis*. 2021;12:2040622320986718. doi:10.1177/2040622320986718
42. Medina-Mirapeix F, Valera-Novella E, Morera-Balaguer J, et al. Prognostic value of the five-repetition sit-to-stand test for mortality in people with chronic obstructive pulmonary disease. *Ann Phys Rehabil Med*. 2022;65(5):101598. doi:10.1016/j.rehab.2021.101598
43. Bernabeu-Mora R, Valera-Novella E, Sánchez-Martínez MP, et al. Improving the reliability between the BODE index and the BODS index in which the 6-min walk test was replaced with the five-repetition sit-to-stand test. *Int J Chron Obstruct Pulmon Dis*. 2022;17:643–652. doi:10.2147/COPD.S347696