Predictive Value and Clinical Application of the 30-Second Sit-to-Stand Test Combined with COPD Assessment Test Score for Exercise-Induced Hypoxemia in COPD Patients: A Postprint Study

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Abstract

Background Chronic obstructive pulmonary disease (COPD) is a common respiratory disease in elderly patients. Decreased peripheral transcutaneous oxygen saturation (SpO2) during activity is a ubiquitous phenomenon correlated with disease prognosis. Currently, assessment conclusions regarding exercise-induced desaturation (EID) are inconsistent. Objective To explore methods suitable for assessing EID in community and home-based COPD patients. Methods Seventy-six stable COPD patients admitted to China-Japan Friendship Hospital from January 2021 to August 2023 were retrospectively selected as study subjects. Resting SpO2 and lowest SpO2 during exercise (ΔSpO2) in the six-minute walk test (6MWT) were recorded, with ΔSpO2 $\geq$ 4% serving as the EID criterion. Patients were divided into non-EID and EID groups based on EID presence. Pulmonary function indices, 30-second sit-to-stand test (30s STST) ΔSpO2, and COPD Assessment Test (CAT) scores were compared between groups. The relationship between 6MWT ΔSpO2 and both 30s STST ΔSpO2 and CAT score was explored. Receiver operating characteristic (ROC) curve analysis was employed to evaluate the predictive value of 30s STST ΔSpO2, CAT score, and their combination for EID. Results Statistically significant differences in 30s STST ΔSpO2 and CAT scores were observed between the non-EID group (n=29) and EID group (n=47) (P<0.05). The 30s STST ΔSpO2 cutoff value for predicting EID was 2, with sensitivity of 59.6%, specificity of 82.8%, and area under the receiver operating characteristic curve (AUC) of 0.730 (95%CI=0.614~0.846, P<0.05). The CAT score cutoff value for predicting EID was 13 points, with sensitivity of 48.9%, specificity of 79.3%, and AUC of 0.712 (95%CI=0.596~0.828, P<0.05). The combination of 30s STST ΔSpO2 and CAT score for predicting

EID was 0.593, with sensitivity of 70.2%, specificity of 72.4%, and AUC of 0.765 (95%CI=0.659~0.871, P<0.001). Conclusion When 30s STST induces a SpO2 decrease ≥ 2% or CAT score ≥ 13 points, vigilance for possible EID is warranted; the 30s STST and CAT score can serve as assessment methods for predicting induced EID in stable COPD patients in community and home settings.

Full Text

Predictive Value of the 30-Second Sit-to-Stand Test Combined with COPD Assessment Test Score for Exercise-Induced Hypoxemia and Its Clinical Application

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Abstract

Background: Chronic obstructive pulmonary disease (COPD) is one of the most common respiratory diseases in elderly patients. Decreased peripheral oxygen saturation (SpO_2) during activity is a common phenomenon correlated with disease prognosis, yet current assessments of exercise-induced hypoxemia (EID) have yielded inconsistent results.

Objective: To explore methods suitable for inducing and assessing EID in community and home-based COPD patients.

Methods: This retrospective study included 76 stable COPD patients admitted to China-Japan Friendship Hospital from January 2021 to August 2023. Resting SpO_2 and the lowest SpO_2 during exercise (ΔSpO_2) were recorded during the six-minute walk test (6MWT), with EID defined as $\Delta SpO_2 \geq 4\%$. Patients were divided into non-EID and EID groups. Pulmonary function indicators, ΔSpO_2 during the 30-second sit-to-stand test (30s STST), and COPD Assessment Test

(CAT) scores were compared between groups. The relationship between ΔSpO_2 in 6MWT and both 30s STST ΔSpO_2 and CAT scores was investigated. Receiver operating characteristic (ROC) curve analysis was used to evaluate the predictive value of 30s STST ΔSpO_2, CAT score, and their combination for EID.

Results: Significant differences were observed between the non-EID group (n=29) and EID group (n=47) in 30s STST ΔSpO_2 and CAT scores (P<0.05). The optimal cutoff value of 30s STST ΔSpO_2 for predicting EID was 2%, with sensitivity of 59.6%, specificity of 82.8%, and area under the curve (AUC) of 0.730 (95%CI=0.614-0.846, P<0.05). The optimal cutoff for CAT score was 13 points, with sensitivity of 48.9%, specificity of 79.3%, and AUC of 0.712 (95%CI=0.596-0.828, P<0.05). The combination of 30s STST ΔSpO_2 and CAT score yielded a cutoff of 0.593, sensitivity of 70.2%, specificity of 72.4%, and AUC of 0.765 (95%CI=0.659-0.871, P<0.001).

Conclusion: A 30s STST-induced SpO_2 decrease $\geq$ 2% or CAT score $\geq$ 13 points should alert clinicians to potential EID. The 30s STST and CAT score can serve as practical assessment tools for predicting EID in stable COPD patients in community and home settings.

Keywords: Pulmonary disease, chronic obstructive; Sit-to-stand test; Hypoxemia; Exercise-induced hypoxemia; Home-based rehabilitation; Forecasting

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Introduction

Chronic obstructive pulmonary disease (COPD) is a heterogeneous lung condition characterized by chronic respiratory symptoms including dyspnea, cough, and sputum production that lead to persistent and progressively worsening airflow limitation. COPD has become the third leading cause of death worldwide. Since 2011, the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines have shifted from purely spirometry-based assessment to incorporate clinical indicators such as symptom evaluation and dyspnea severity. Peripheral oxygen saturation (SpO_2) is a crucial respiratory parameter reflecting hypoxia status. Exercise-induced hypoxemia (EID) is clinically defined as a difference between resting SpO_2 and the lowest SpO_2 during exercise (ΔSpO_2) $\geq$ 4% and/or minimum SpO_2 < 90% during six-minute walk testing (6MWT) or cardiopulmonary exercise testing (CPET). EID etiology is multifactorial, involving ventilation-perfusion mismatch, alveolar hypoventilation, diffusion limitation, and decreased oxygen content in mixed venous blood. Patients with EID typically exhibit severe airflow limitation, reduced carbon monoxide diffusing capacity (DLCO), decreased resting arterial oxygenation, and emphysema. Hypoxemia is associated with impaired exercise capacity and increased mortality.

Current clinical measurements for EID include monitoring resting SpO_2, forced expiratory volume in one second (FEV_1), and DLCO, but these have limitations

for community and home implementation. There is an urgent need for simple, direct EID assessment methods. This study investigates the correlation between EID during 6MWT and both the 30-second sit-to-stand test (30s STST) and COPD Assessment Test (CAT) score in stable COPD patients, aiming to identify simple and accurate methods for predicting EID in community or home settings.

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1. Materials and Methods

1.1 Study Population We retrospectively selected 76 stable COPD patients admitted to China-Japan Friendship Hospital between January 2021 and August 2023 as study subjects.

1.2 Inclusion and Exclusion Criteria **Inclusion criteria:** (1) Diagnosis and severity classification of COPD followed the 2021 GOLD guidelines, with all patients meeting diagnostic criteria and being in stable condition; (2) Completion of 6MWT, 30s STST, and CAT score assessments.

Exclusion criteria: Patients were excluded based on absolute and relative contraindications specified in the Chinese Expert Consensus on Clinical Application of the Six-Minute Walk Test. The study was approved by the Clinical Research Ethics Committee of China-Japan Friendship Hospital (approval number: 2022-KY-141), and all participants provided informed consent.

1.3 Measurement Indicators and Methods **1.3.1 Demographic data:** Patient demographics (age, sex) and anthropometric data (height, weight) were collected from pulmonary function reports to calculate body mass index (BMI).

1.3.2 Measurement indicators and methods: (1) Pulmonary function tests were performed by qualified technicians according to standard protocols. (2) The 6MWT was used to evaluate exercise capacity, treatment efficacy, and prognosis. Testing was conducted in a quiet 30-meter corridor with minimal pedestrian traffic. Patients were instructed to walk at their maximum capacity for 6 minutes, adjusting speed as needed. Resting SpO_2 and the lowest SpO_2 during exercise were recorded to calculate ΔSpO_2, with EID defined as $\Delta SpO_2 \geq 4\%$. Trained hospital staff supervised the test according to guideline requirements. (3) The 30s STST was used to measure lower limb muscle strength. A standardized chair with a seat height of 47 cm from the floor was placed against a wall for stability. Patients sat with feet flat on the floor and arms crossed at the chest. Upon the "start"signal, patients performed repeated sit-to-stand cycles without using their arms for assistance, completing as many repetitions as possible within 30 seconds. A complete cycle required standing fully and then sitting until touching the seat. Staff recorded resting SpO_2, minimum SpO_2 during the test, number of repetitions, and fatigue level. (4) The CAT score supplemented spirometry data for risk assessment, evaluating eight dimensions including cough, sputum,

chest tightness, breathlessness, activity limitation, confidence, sleep, and energy. It quantifies health status and symptom burden in COPD patients, with total scores of 0–10, 11–20, 21–30, and 31–40 representing mild, moderate, severe, and very severe clinical impact, respectively.

1.4 Statistical Analysis Data were processed and analyzed using SPSS 26.0 software. Normally distributed continuous variables were expressed as mean ± standard deviation and compared between groups using independent t-tests. Non-normally distributed variables were presented as median (P_{25}, P_{75}) and compared using Mann-Whitney U tests. Categorical data were expressed as frequencies and compared using ^{2} tests. ROC curve analysis evaluated the predictive value of 30s STST ΔSpO_2 and CAT score for 6MWT ΔSpO_2. Statistical significance was set at $P<0.05$.

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2. Results

2.1 General Characteristics The 76 stable COPD patients ranged in age from 32 to 87 years, with a mean age of $(64\$\pm10) years. BMI ranged from 17.3 to 29.9 kg/m^{\{2\}, with a mean of (24.4±3.1}$ No significant differences were observed between groups in sex, age, or BMI ($P>0.05$) .

2.2 Comparison of 30s STST ΔSpO_2, CAT Scores, and Pulmonary Function Indicators Significant differences were found between the non-EID and EID groups in 30s STST ΔSpO_2, CAT score, DLCO/SB%pred, and DLCO/VA%pred ($P<0.05$). No significant differences were observed in FEV_1/FVC ratio, FEV_1%pred, peak expiratory flow (PEF), MEF_{25}, MEF_{50}, or $MMEF_{75}/_{25}$ between groups ($P>0.05$) .

2.3 Predictive Value of 30s STST ΔSpO_2, CAT Score, and Their Combination The optimal cutoff value of 30s STST ΔSpO_2 for predicting EID was 2%, with sensitivity of 59.6%, specificity of 82.8%, and AUC of 0.730 (95%CI=0.614–0.846, $P<0.05$). The optimal cutoff for CAT score was 13 points, with sensitivity of 48.9%, specificity of 79.3%, and AUC of 0.712 (95%CI=0.596–0.828, $P<0.05$). The combination of 30s STST ΔSpO_2 and CAT score yielded a cutoff of 0.593, sensitivity of 70.2%, specificity of 72.4%, and AUC of 0.765 (95%CI=0.659–0.871, $P<0.001$) [Figure 1: see original paper].

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3. Discussion

EID is a recognized risk factor for mortality and disease exacerbation in COPD. Compared to non-EID patients, those with EID exhibit more severe emphysema on quantitative CT imaging and face a 2.4–2.7-fold higher mortality risk. EID in COPD is associated with reduced exercise capacity, severe airflow limitation,

ventilation-perfusion mismatch, dynamic hyperinflation, impaired diffusion capacity, decreased muscle strength, and limited daily activity. Chronic hypoxemia, a sequela of COPD, can lead to pulmonary hypertension, neurocognitive dysfunction, secondary polycythemia, systemic inflammation, skeletal muscle dysfunction, bone loss, and depression, further reducing quality of life, exercise tolerance, and increasing cardiovascular and mortality risks. Therefore, assessing EID in community and home settings has important clinical significance.

The sit-to-stand test was first described in 1985 as a functional assessment tool, with its application in COPD patients beginning in 2007. Recent studies have investigated correlations between STST and 6MWT distance, grip strength, quadriceps muscle strength, St. George' s Respiratory Questionnaire, CAT score, modified Medical Research Council dyspnea scale, and prognostic indices (BODE and ADO), demonstrating significant relationships. Traditional EID prediction requires expensive pulmonary function equipment and specialized technicians, while 6MWT demands substantial space, necessitating visits to tertiary hospitals with associated time costs and risks. The 30s STST requires no special venue or equipment—only a chair and pulse oximeter—making it easily manageable, ideal as a 6MWT alternative for community and home use. Previous studies have correlated 30s STST with muscle strength and exercise tolerance but did not examine SpO_2 changes. Our study demonstrates that 30s STST ΔSpO_2 differs between non-EID and EID groups and correlates with 6MWT ΔSpO_2 changes. With a cutoff of 2%, sensitivity of 59.6%, specificity of 82.8%, and AUC of 0.730, community physicians or patients can self-administer the 30s STST; a SpO_2 drop exceeding 2% indicates EID risk requiring clinical intervention to prevent chronic functional impairment.

The CAT score provides clinicians and patients with a simple, reliable health status measure that complements spirometry, assesses exacerbation risk, and facilitates disease severity consensus to optimize management. Previous research has correlated CAT scores with GOLD stages, airflow limitation, and DLCO. Our study demonstrates that CAT scores also correlate with and predict EID in COPD patients, with an optimal cutoff of 13 points. During self-assessment, scores $ $13 indicate EID risk. Compared to other COPD-specific quality-of-life scales, CAT is less time-consuming and essential for GOLD classification, enhancing practical utility.

Combining the 30s STST (capacity test) with CAT scoring (questionnaire assessment) in community and home settings compensates for subjective limitations, improving EID prediction and reducing exercise risks while identifying needs for oxygen therapy or hospital referral. With global digital transformation, telerehabilitation using communication technologies has emerged as a research focus. COPD patients, predominantly elderly with multiple comorbidities (cardiovascular disease, obstructive sleep apnea, hypertension, diabetes), face increased infection risks and consequently reduce social and outdoor activities, leading to abdominal obesity, poor muscle quality, decreased cardiopulmonary endurance, and depression. The shift from traditional outpatient and inpatient rehabilita-

tion to intelligent remote and home-based models represents a future research direction. STST and CAT require no large equipment, serving as rapid, effective assessment tools for tracking patient function and health status.

This study has limitations. The sample size was small, and the single-center design may introduce selection bias. CAT scores may be influenced by patients' educational levels and subjective perceptions. Variations in patient height and leg length may affect standardization of chair height in the 30s STST, and we did not perform subgroup analyses; gender effects remain unclear. Future multi-center, large-sample studies are needed.

In conclusion, 6MWT ΔSpO_2 correlates with 30s STST ΔSpO_2 and CAT scores. The combination of 30s STST and CAT score serves as an important supplementary tool for predicting EID in stable COPD patients, offering valuable assessment methods for community rehabilitation and tele-rehabilitation that warrant broader implementation.

Author Contributions: YANG Tianyi conceptualized the study, designed the research, implemented the investigation, and wrote the original draft. SITU Xuanming and QUMU Shiwei collected and curated data, performed statistical analysis, and created visualizations. WANG Siyuan reviewed and edited the manuscript. JIANG Shan and YANG Ting supervised the project and ensured quality control.

Conflict of Interest: The authors declare no conflicts of interest.

References

[1] AGUSTÍ A, CELLI B R, CRINER G J, et al. Global initiative for chronic obstructive lung disease 2023 report: gold executive summary[J]. Eur Respir J, 2023, 61(4): 2300239. DOI: 10.1183/13993003.00239-2023.

[2] BARTZIOKAS K, PAPAPORFYRIOU A, HILLAS G, et al. Global initiative for chronic obstructive lung disease (GOLD) recommendations: strengths and concerns for future needs[J]. Postgrad Med, 2023, 135(4): 327-333. DOI: 10.1080/00325481.2022.2135892.

[3] YANG L L, SHI M H, SITU X M, et al. Prediction of exercise-induced desaturation in COPD patients without resting hypoxemia: a retrospective study[J]. BMC Pulm Med, 2022, 22(1): 405. DOI: 10.1186/s12890-022-02174-w.

[4] DEL CASTILLO J G, CANDEL F, DE LA FUENTE J I, et al. Manejo integral del paciente con exacerbación aguda de la enfermedad pulmonary[J]. Revista Española De Quimioterapia, 2018, 31: 461-484.

[5] LIDÉN M, HJELMGREN O, VIKGREN J, et al. Multi-reader-multi-split annotation of emphysema in computed tomography[J]. J Digit Imaging, 2020, 33(5): 1185-1193. DOI: 10.1007/s10278-020-00378-2.

[6] KIM C, KO Y, LEE J S, et al. Predicting long-term mortality with two different criteria of exercise-induced desaturation in COPD[J]. Respir Med, 2021, 182: 106393. DOI: 10.1016/j.rmed.2021.106393.

[7] 中华医学会呼吸病学分会慢性阻塞性肺疾病学组, 中国医师协会呼吸医师分会慢性阻塞性肺疾病工作委员会. 慢性阻塞性肺疾病诊治指南 (2021 年修订版)[J]. 中华结核和呼吸杂志, 2021, 44(3): 170-205. DOI: 10.3760/cma.j.cn112147-20210221-00121.

[8] 中华医学会老年医学分会. 老年患者 6 分钟步行试验临床应用中国专家共识 [J]. 中华老年医学杂志, 2020, 39(11): 1241-1250. DOI: 10.3760/cma.j.issn.0254-9026.2020.11.001.

[9] ATS COMMITTEE ON PROFICIENCY STANDARDS FOR CLINICAL PULMONARY FUNCTION LABORATORIES. ATS statement: guidelines for the six-minute walk test[J]. Am J Respir Crit Care Med, 2002, 166(1): 111-117. DOI: 10.1164/ajrccm.166.1.at1102.

[10] 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[J]. Respir Care, 2019, 64(10): 1261-1269. DOI: 10.4187/respcare.06694.

[11] ELBEHAIRY A F, GUENETTE J A, FAISAL A, et al. Mechanisms of exertional dyspnoea in symptomatic smokers without COPD[J]. Eur Respir J, 2016, 48(3): 694-705. DOI: 10.1183/13993003.00077-2016.

[12] SARI C P, HANIFAH S, ROSDIANA R, et al. The COPD (chronic obstructive pulmonary disease) assessment test: assessment of therapeutic outcomes of patients at private hospitals in Yogyakarta[J]. J Pharm Bioallied Sci, 2020, 12(Suppl 2): S821-S825. DOI: 10.4103/jpbs.JPBS_{{{302}}}_{{19}}}.

[13] GUPTA R, RUPPEL G L, ESPIRITU J R D. Exercise-induced oxygen desaturation during the 6-minute walk test[J]. Med Sci, 2020, 8(1): 8. DOI: 10.3390/medsci8010008.

[14] GARCÍA-TALAVERA I, FIGUEIRA-GONÇALVES J M, GOLPE R, et al. Early desaturation during 6-minute walk test is a predictor of mortality in COPD[J]. Lung, 2023, 201(2): 217-224. DOI: 10.1007/s00408-023-00613-x.

[15] LEE K Y, WU S M, KOU H Y, et al. Association of air pollution exposure with exercise-induced oxygen desaturation in COPD[J]. Respir Res, 2022, 23(1): 77. DOI: 10.1186/s12931-022-01986-2.

[16] KENT B D, MITCHELL P D, MCNICHOLAS W T. Hypoxemia in patients with COPD: cause, effects, and disease progression[J]. Int J Chron Obstruct Pulmon Dis, 2011, 6: 199-208. DOI: 10.2147/COPD.S10611.

[17] CSUKA M, MCCARTY D J. Simple method for measurement of lower extremity muscle strength[J]. Am J Med, 1985, 78(1): 77-81. DOI: 10.1016/0002-9343(85)90465-6.

[18] OZALEVLI S, OZDEN A, ITIL O, et al. Comparison of the sit-to-stand test with 6 min walk test in patients with chronic obstructive pulmonary disease[J].

Respir Med, 2007, 101(2): 286-293. DOI: 10.1016/j.rmed.2006.05.007.

[19] VAIDYA T, CHAMBELLAN A, DE BISSCHOP C. Sit-to-stand tests for COPD: a literature review[J]. Respir Med, 2017, 128: 70-77. DOI: 10.1016/j.rmed.2017.05.003.

[20] KAKAVAS S, PAPANIKOLAOU A, KOMPOGIORGAS S, et al. The correlation of sit-to-stand tests with COPD assessment test and GOLD staging classification[J]. COPD, 2020, 17(6): 655-661. DOI: 10.1080/15412555.2020.1825661.

[21] ZHANG Q, LI Y X, LI X L, et al. A comparative study of the five-repetition sit-to-stand test and the 30-second sit-to-stand test to assess exercise tolerance in COPD patients[J]. Int J Chron Obstruct Pulmon Dis, 2018, 13: 2833-2839. DOI: 10.2147/COPD.S173509.

[22] GIL H I, ZO S, JONES P W, et al. Clinical characteristics of COPD patients according to COPD assessment test (CAT) score level: cross-sectional study[J]. Int J Chron Obstruct Pulmon Dis, 2021, 16: 1509-1517. DOI: 10.2147/COPD.S297089.

[23] BANSODE P M, KUMAR C, M S. Usefulness of cat score in patients with stable copd and acute exacerbation of copd and it' s co-relation with PFT[J]. J Assoc Physicians India, 2022, 70(4): 11-12.

[24] GALDIZ J B, GÓMEZ A, RODRIGUEZ D, et al. Telerehabilitation programme as a maintenance strategy for COPD patients: a 12-month randomized clinical trial[J]. Arch Bronconeumol, 2021, 57(3): 195-204. DOI: 10.1016/j.arbres.2020.03.034.

[25] TSUTSUI M, GERAYELI F, SIN D D. Pulmonary rehabilitation in a post-COVID-19 world: telerehabilitation as a new standard in patients with COPD[J]. Int J Chron Obstruct Pulmon Dis, 2021, 16: 379-391. DOI: 10.2147/COPD.S263031.

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Note: Figure translations are in progress. See original paper for figures.