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Adherence,Satisfaction,Inhaler Technique,and Inspiratory Performance in Patients With Chronic Obstructive Pulmonary Disease:A Cross-Sectional Study

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Research Article

Keywords: medication adherence, patient satisfaction, inhalation devices, respiratory function tests, chronic obstructive pulmonary disease

Posted Date: November 1st, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11268300/v1

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Additional Declarations: No competing interests reported.

Abstract

Background: Adherence, satisfaction, medication accuracy, and the ability to self-administer inhaled medications among patients with Chronic Obstructive Pulmonary Disease(COPD) directly impact the effectiveness of drug therapy.Therefore, this study aims to examine the current levels of adherence, satisfaction, medication accuracy, the ability to self-administer inhaled medications , and symptom control among patients with COPD, and to analyze the correlations among these factors.

Methods: A cross-sectional survey was conducted at a single tertiary hospital in Xinjiang, China(July 2025-April 2026). Symptom burden (COPD Assessment Test [CAT]), adherence (Test of Adherence to Inhalers [TAI]), and satisfaction (Feeling of Satisfaction with Inhaler-10 [FSI-10]) were assessed in 141 patients with COPD. Inhaler technique was objectively evaluated in 65 patients using a locally developed assessment form;peak inspiratory flow (PIF) and effective inhalation time (EIT) were measured in 44 patients using a respiratory rehabilitation trainer. Overlap between the objective-assessment subgroups and the questionnaire cohort was incomplete.

Results: Patients reported moderate disease burden (CAT: 17.09 ± 5.97) and low adherence (TAI: 44.21 ± 7.24), yephigh satisfaction (FSI-10: 46.59 ± 3.50). Satisfaction correlated positively with adherence (r = 0.423, P < 0.001). Only 13 / 65(20.00%) demonstrated proficient inhaler technique. Among 44 tested patients, 30 (68.18%) had subthreshold minimum effective PIF and 40 (90.91%) had insufficient effective inhalation time.

Conclusion: Despite high satisfaction, patients with COPD showed low adherence and poor objective inhaler proficiency and inspiratory performance, indicating a gap between perceived and actual inhaler use. These exploratory findings are hypothesis-generating and warrant confirmation in larger, prospective studies.

Trial Registration: Chinese Clinical Trial Registry; NO.: ChiCTR2600116969;Registration date: 2026-01-18 URL: http://www.chictr.org.cn

Background

Chronic obstructive pulmonary disease (COPD) is a heterogeneous lung disease characterized by chronic respiratory symptoms resulting from abnormalities in the airways and/or alveoli, leading to persistent airflow limitation[1, 2].China has nearly 100 million people with COPD, with a prevalence of 8.6% among those aged 20 and older and 13.7% among those aged 40 and older.COPD is a major cause of death and imposes a heavy burden on patients, their families, and society[3]. In the treatment of COPD, long-term, regular use of inhaled medications is the primary therapeutic approach[4]. Despite the availability of various inhaled therapies, real-world exacerbation rates remain high, largely due to suboptimal medication adherence and poor device handling[5, 6].Furthermore, the increasing prevalence of "device polypharmacy"—where patients are prescribed multiple inhalers with different operating mechanisms (e.g. combining dry powder inhalers [DPIs] with pressurized metered-dose inhalers

[pMDIs])—often leads to patient confusion and a higher frequency of critical handling errors[7–10].Therefore, evaluating the multifaceted aspects of inhalation therapy from the patient's perspective is crucial for primary care providers to optimize treatment outcomes.

However, most previous studies have assessed adherence, satisfaction, and inhaler technique separately, and few have evaluated patient-reported satisfaction and adherence alongside objectively measured inhaler technique and inspiratory performance in the same clinical setting. In the present study, the term “fit” is used to describe the conceptual concordance among a patient’s perceived competence, their actual inhaler technique, and their physiological inspiratory capacity; it is a conceptual framework rather than a directly measured outcome. PIF and EIT are critical for the effective delivery of drugs via DPIs, which require a forceful and deep inhalation to disaggregate the powder into respirable particles; accordingly, inadequate inspiratory capacity can result in ineffective drug delivery despite the patient reporting satisfaction or confidence. We therefore hypothesized that high perceived satisfaction may not correspond to correct inhaler use or adequate inspiratory performance.

In this exploratory study, we recruited patients with COPD receiving inhalation therapy. Using the CAT, TAI, FSI-10, an Inhalation Technique Assessment Form, and a respiratory rehabilitation trainer, we collected data on symptom burden, subjective adherence, satisfaction with inhaled medications, accuracy of inhaler use, and self-administration ability among patients with COPD, and analyzed the relationships among these factors. Given the exploratory cross-sectional design, all findings should be interpreted as hypothesis-generating rather than definitive.

Material and methods

Research Objective

To examine the current status of adherence, satisfaction, accuracy of inhaler use, and symptom control among patients with COPD and to explore the relationships among these factors. Given the exploratory cross-sectional design, the study was intended to generate hypotheses rather than to establish causal relationships.

Research Design

Cross-sectional survey.

Study Population

Patients with COPD who received outpatient or inpatient care at the First Affiliated Hospital of Shihezi University in Shihezi City, Xinjiang Uygur Autonomous Region, China, between July 2025 and April 2026 were recruited and analyzed.

Inclusion criteria

(1) Age ≥ 18 years; (2) diagnosis of COPD according to the 2026 Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines; (3) treatment with inhaled medications; (4) agreement to participate in the study, undergo pulmonary function testing, and sign an informed consent form.

Exclusion criteria

(1) Individuals with communication difficulties due to hearing impairment or inability to express themselves; (2) patients with mental disorders.

The assessment of drug tolerance requires further exclusion of the following: (1) massive hemoptysis within the past 4 weeks; (2) severe heart failure, severe arrhythmia, or unstable angina within the past 4 weeks; (3) systolic blood pressure > 200 mmHg and diastolic blood pressure > 100 mmHg; (4) myocardial infarction, stroke, or shock within the past 3 months; (5) aortic aneurysm; (6) severe hyperthyroidism; (7)heart rate > 120 beats per minute; (8) pneumothorax or pulmonary bullae not scheduled for surgical treatment; (9) pregnant.

Research Process

Outpatients and inpatients with COPD who met the inclusion and exclusion criteria were recruited for this study. Trained researchers explained the study objectives to the patients and guided them through the process of signing the informed consent form. Each patient then completed the CAT, TAI, and FSI-10 questionnaires, which took approximately 15 minutes. Researchers used the Inhalation Technique Assessment Form to evaluate patients' accuracy in using inhaled medications, requiring patients to demonstrate the correct use of their current inhaler; this assessment was completed by 65 patients. Inspiratory capacity was additionally assessed in 44 eligible patients using a respiratory rehabilitation trainer. The objective assessments were performed in the subset of participants who consented and were able to complete the procedures during the study visit; consequently, the overlap between the objective-assessment subgroups and the questionnaire cohort was incomplete, as detailed in the Results.

Research Tools

The CAT,developed by Jones et al. in 2009,is a well-validated instrument for assessing and monitoring COPD[11]. It possesses good measurement characteristics, is sensitive to variations in symptoms, and serves as an effective, reliable, and standardized measure of COPD health status (Appendix-1). The scale consists of 8 items, with a score of 0 indicating minimal symptom impact and a score of 5 indicating severe symptom impact. The total score ranges from 0 to 40, with higher scores indicating a greater negative impact of COPD on the patient. Based on the score, the severity of the disease burden is

classified into four levels: mild burden (0–10 points), moderate burden (11–20 points), severe burden (21–30 points), and very severe burden (31–40 points).

The TAI developed and published by Plaza et al. in 2016, is specifically designed to assess adherence to inhaled medications among patients with COPD and asthma[12] (Appendix-2). The scale consists of 10 items organized into two dimensions: “Unintentional”(items1-5) and “Intentional”(item6-10). Items 1–5 indicate that poor adherence stems from occasional patient behavior that may be unrelated to the medication itself; items 6–10 indicate that poor adherence stems from deliberate patient behavior that may be related to defects in the medication itself. All items use a 5-point Likert scale, where 1 indicates “always” and 5 indicates “never.” The total score ranges from 10 to 50 points,with a lower score indicating poorer adherence. Adherence is classified into three levels: high (50 points), moderate(46–49 points), and low(≤ 45 points).

The FSI-10, developed by Perpiñá Tordera et al.in 2008,assesses satisfaction with inhaled medications among patients with COPD and asthma[13] (Appendix-3). The scale consists of 10 items covering dimensions such as ease of use, portability, and comfort of the inhaler. Using a 5-point Likert scale(5 = very satisfied;1 = very dissatisfied).The total score ranges from 10 to 50, with lower scores indicating lower satisfaction. A score of ≥ 40 indicates high satisfaction, while a score < 40 indicates low satisfaction.

The COPD Inhalation Technique Assessment Form, developed for this study used to evaluate the accuracy with which patients with COPD use inhalation devices (Appendix-4). The form comprises three sections: patient demographics, device operation assessment, and the clinical pharmacist’s summary and recommendations, and is scored out of 100 points. A score of 100 indicates that the patient has mastered the current inhaler technique; 80–99, a basic grasp; 60–79, an inadequate grasp; and < 60, no grasp. It should be noted that this form was developed locally; although it was refined through a Delphi process, formal inter-rater reliability testing has not yet been fully established, which represents a limitation that should be considered when interpreting the inhaler-technique results.

Ability to inhale medication was assessed by trained researchers using a respiratory rehabilitation trainer (manufactured by Zhejiang Yiliankang Medical Technology Co. Ltd., model PE100). Three parallel measurements were taken, and the best result was recorded. PIF and EIT were compared against device-specific PIF requirements and standard thresholds for the minimum effective PIF, defined according to the manufacturers’ specifications and published literature; the specific threshold values applied are summarized in Supplementary Table S1.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics Version 25.0. Continuous variables are expressed as mean ± standard deviation (mean ± SD), and categorical variables as frequency and percentage. The Kolmogorov–Smirnov test was used to assess the normality of continuous data. For

normally distributed continuous data, an independent-samples t-test was used to compare two groups; for non-normally distributed data, the Mann–Whitney U test was used. The chi-square test was used for categorical comparisons, with Fisher's exact test applied when expected cell counts were sparse. Correlations among CAT, TAI, and FSI–10 were assessed using Pearson correlation coefficients for variables that satisfied normality assumptions; Spearman's rank correlation was used where normality was violated. In addition to P values, 95% confidence intervals (CIs) are reported for key estimates, and Cohen's d was computed as an effect size for group comparisons.

No formal a priori sample size calculation was performed. Post-hoc power analysis based on the observed correlations indicated that the full cohort (n = 141) had high power (approximately 100%) to detect the association between satisfaction and adherence (r = 0.423), whereas the combined-analysis subgroup (n = 30) was substantially underpowered (estimated power < 40% for the observed correlations); results from these small subgroups should therefore be interpreted cautiously. Because the study was exploratory, no adjustment was made for multiple comparisons, and all significant findings should be regarded as exploratory. All significance levels were two-tailed, and $P < 0.05$ was considered statistically significant.

Results

This study included a total of 141 patients with COPD, of whom 90 were male (63.83%,95% CI 55.6%-71.3%), with a mean age of (72.47 ± 8.83) years. Patients used 9 types of inhaled medications. Baseline characteristics are described in (Table 1).

Table 1
Patient's baseline characteristics

Variables	Total (n = 141)
Age, Mean ± SD	72.47 ± 8.828
Gender, n(%)	
Male	90 (63.83)
Female	51 (36.17)
Use inhaler [a], n(%)	
BUD/GLY/FOR	40 (28.37)
IND/GLY	37 (26.24)
FF/UMEC/VI	33 (23.40)
SAL/FLU	11 (7.80)
BUD/FOR	7 (4.96)
UMEC/VI	6 (4.26)
TIO	4 (2.84)
GLY/FOR	2 (1.42)
BEC/FOR/GLY	1 (0.71)

SD: standard deviation

[a] BUD/GLY/FOR:Budesonide/glycopyrronium bromide/formoterol fumarate inhalation aerosol;IND/GLY:Indacaterol/glycopyrronium bromide inhalation powder;FF/UMEC/VI:Fluticasone furoate/vilanterol/umeclidinium bromide inhalation powder;SAL/FLU:Salmeterol/fluticasone propionate inhalation powder;BUD/FOR:Budesonide/formoterol fumarate inhalation powder;UMEC/VI:Umeclidinium bromide/vilanterol inhalation powder;TIO:Tiotropium bromide inhalation powder;GLY/FOR:Glycopyrronium bromide/formoterol fumarate inhalation aerosol;BEC/FOR/GLY:Beclometasone Dipropionate,Formoterol Fumarate and Glycopyrrolate Inhalation Aerosol

Patient disease burden (CAT)

The mean CAT score was 17.09 ± 5.974(95% CI 16.10-18.08), indicating a moderate overall disease burden. In total, 18 patients (12.77%) with a mild burden, 83 patients (58.87%) a moderate burden, 38 (26.95%)a severe burden, and 2(1.42%) a very severe burden. Overall, 87.23% of patients experienced a moderate or higher symptom burden, suggesting that symptom control among these patients was not yet optimal.

Patient Medication Adherence (TAI)

The mean TAI score was 44.21 ± 7.239(95% CI 43.00-45.42), indicating an overall low level of adherence.In total 31 patients 21.99%(95% CI 15.9%-29.5%) had high adherence, 58 (41.13%,95% CI 33.4%-49.4%) moderate adherence, and 52 (36.88%,95% CI 29.4%-45.1%) low adherence.Among all items, Item 3 (“Do you stop using your inhaler when you feel well?”) had the lowest average score (3.97) (Fig. 1), indicating that many patients lacked awareness of the importance of long-term maintenance therapy with inhaled medications. Because the total scores for the “unintentional” (items 1–5) and “intentional” (items 6–10) dimensions did not follow a normal distribution, nonparametric tests were used for comparison. The mean score for “unintentional” nonadherence was 21.38 ± 5.11, and that for “intentional” non-adherence was 22.80 ± 2.616($Z = -11.944$, $P < 0.001$), indicating that “unintentional”non-adherence predominated.

Patient Satisfaction with Medications (FSI-10)

The mean FSI-10 score was 46.59 ± 3.50 (95% CI 46.01–47.17), indicating a high overall level of satisfaction. In total, 135 patients (95.7%, 95% CI 91.0%–98.0%) reported high satisfaction, while 6 (4.3%) reported low satisfaction. Among all items, Item 9 (“After using the inhaler, do you think you used it correctly this time?”) received the lowest score (3.87) (Fig. 2), indicating that most patients lacked standardized training and were not fully proficient in the steps for operating the inhaler.

Assessment of Operational Accuracy for Inhalation Formulations (Patient Behavior)

The Inhalation Technique Assessment Form was used to evaluate the operation of inhalation devices by 65 patients. The mean score was 84.94 ± 12.82(95% CI 81.76–88.12). According to clinical pharmacists’ assessments, only 13 patients (20.00%,95% CI 12.1–31.3%) demonstrated proficiency in operating their devices;and 25 patients (38.46%,95% CI 23.5%-46.0%) were considered uncertain or unsuitable for using their current inhalers based on the overall evaluation. Operational were most frequently observed for failure to exhale before inhalation(27 patients,41.5%,95% CI 30.4–53.7%)and failure to hold the breath after inhalation (23 patients, 35.4%, 95% CI 24.9–47.5%) (Table 2).

Table 2
Evaluation of the Accuracy of Inhalation Device Operation

Variables	Total (n = 65)
Age, Mean ± SD	71.66 ± 10.28
Gender, n(%)	
Male	34 (52.31)
Female	31 (47.69)
Duration of medication use (years), Mean ± SD	1.443 ± 2.36
Inhaler Operation Score	
Preparation(20 points), Mean ± SD	17.63 ± 4.23
Inhalation (65 points), Mean ± SD	53.72 ± 10.60
Tidying Up (15 points), Mean ± SD	13.43 ± 2.77
Total Score(100 points), Mean ± SD	84.94 ± 12.82
Pharmacist Assessment, n(%)	
mastered	13 (20.00)
basic grasp	32 (49.23)
inadequate grasp	19 (29.23)
no grasp	1 (1.54)
Overall Evaluation, n(%)	
appropriate	40 (61.54)
It is unclear whether further evaluation is needed	22 (33.85)
Not suitable	3 (4.62)
Pharmacist's Advice, n(%)	
Continue using	20 (30.77)
Intensify training	43 (66.15)
Consider replacing the device	2 (3.08)
SD: standard deviation	

Assessment of Drug Absorption Capacity (patient's physical capabilities)

After assessing inspiratory capacity in 44 patients, 23 (52.27%,95% CI 37.9%-66.2%) met the PIF requirements of their prescribed devices,whereas 30 (68.18%,95%CI 53.4–80.0%) had a minimum effective PIF(MEPIF) below the standard threshold and 40 (90.91%,95% CI 78.8–96.4%) had an insufficient EIT (Table 3).

Table 3
Assessment of Drug Absorption: Patient's baseline characteristics

Variables	**Total (n = 44)**
Age, Mean ± SD	69.25 ± 8.38
Gender, n(%)	
Male	30 (68.18)
Female	14 (31.82)
Use inhaler [a], n(%)	
BUD/GLY/FOR	17 (38.64)
IND/GLY	10 (22.73)
BUD/FOR	6 (13.64)
FF/UMEC/VI	5 (11.36)
GLY/FOR	2 (4.55)
UMEC/VI	2 (4.55)
BEC/FOR/GLY	1 (2.27)
TIO	1 (2.27)

SD: standard deviation

[a] BUD/GLY/FOR:Budesonide/glycopyrronium bromide/formoterol fumarate inhalation aerosol;IND/GLY:Indacaterol/glycopyrronium bromide inhalation powder;FF/UMEC/VI:Fluticasone furoate/vilanterol/umeclidinium bromide inhalation powder;SAL/FLU:Salmeterol/fluticasone propionate inhalation powder;BUD/FOR:Budesonide/formoterol fumarate inhalation powder;UMEC/VI:Umeclidinium bromide/vilanterol inhalation powder;TIO:Tiotropium bromide inhalation powder;GLY/FOR:Glycopyrronium bromide/formoterol fumarate inhalation aerosol;BEC/FOR/GLY:Beclometasone Dipropionate,Formoterol Fumarate and Glycopyrrolate Inhalation Aerosol

Analysis of the Correlation Among Disease Burden, Satisfaction, and Adherence

Correlation analyses among disease burden, satisfaction, and adherence are shown in Table 4 and Fig. 3. CAT correlated negatively with TAI (r = − 0.232, 95% CI − 0.383 to − 0.069, P = 0.006) and with FSI-10 (r = − 0.261, 95% CI − 0.409 to − 0.100, P = 0.002), indicating that greater disease burden was associated with

lower adherence and lower satisfaction. TAI correlated positively with FSI-10 (r = 0.423, 95% CI 0.277–0.550, P < 0.001), indicating that higher satisfaction was associated with higher adherence.

Table 4
Results of the correlation test(n = 141)

		CAT	TAI	FSI−10
CAT	r(95% CI)	1	−0.232 (−0.383,−0.069)**	−0.261 (−0.409,−0.100)*
	P value		0.006	0.002
TAI	r(95% CI)	−0.232 (−0.383,−0.069)**	1	0.423 (0.277,0.550)**
	P value	0.006		< 0.001
FSI−10	r(95% CI)	−0.261 (−0.409,−0.100)*	0.423 (0.277,0.550)**	1
	P value	0.002	< 0.001	

*r, Pearson correlation coefficient; 95% CI, Fisher z-transformed 95% confidence interval. *P < 0.01; **P < 0.001.*

Analysis of the Correlation Between Device Operational Accuracy and Adherence, Satisfaction, and Disease Burden

Due to the numerous limitations associated with pulmonary function, only 30 patients completed the inhaler technique assessment and questionnaire.Based on clinical pharmacist evaluations, these patients were divided into a proficient group (n = 10) and a non-proficient group (n = 20). The proficient group was significantly younger (63.90 ± 11.11 vs. 74.35 ± 9.08 years; mean difference 10.45 years, 95% CI 2.69–18.21; Cohen's d = 1.07; P = 0.010). No significant differences were observed between the two groups in CAT, TAI, or FSI-10 scores (Table 5). Correlation analysis between the total inhalation accuracy score and CAT, TAI, and FSI-10 scores revealed no statistically significant correlations (all P > 0.05); however, the small sample size (n = 30) provided limited statistical power (estimated power < 40%) to detect such associations, and these negative findings should be interpreted cautiously (Table 6).

Table 5
Comparison of Groups by Proficiency Level

Variables	Total (n = 30)	not proficient (n = 20)	proficient (n = 10)	Mean difference (95% CI)	Cohen's d	*P*
Age	70.87 ± 10.84	74.35 ± 9.08	63.90 ± 11.11	10.45(2/69,18.21)	1.07	0.010
CAT	15.93 ± 4.80	16.70 ± 4.78	14.40 ± 4.70	2.30(−1.47,6.07)	0.48	0.222
TAI	44.13 ± 6.44	45.10 ± 6.34	42.20 ± 6.53	2.90(−2.18,7.98)	0.45	0.252
FSI,	46.63 ± 2.72	46.75 ± 3.11	46.40 ± 1.84	0.35(−1.84,2.54)	0.13	0.746

Data are mean ± SD. Independent-samples t-test; 95% CI of the mean difference; Cohen's d for effect size.

Table 6
Correlation Between Total Inhalation Test Scores and CAT, TAI, and FSI-10(n = 30)

r(95%CI)	Total Inhalation Test Scores	CAT	TAI	FSI-10
	1	**-0.149**	**-0.022**	**0.297**
		(-0.483,0.223)	**(-0.379,0.341)**	**(-0.071,0.594)**
P value		0.431	0.906	0.111

r, Pearson correlation coefficient; 95% CI, Fisher z-transformed 95% confidence interval. Estimated statistical power for these correlations was < 40%; negative findings should be interpreted cautiously.

Discussion

In this exploratory study, 87.23% of patients experienced a moderate or severe symptom burden associated with COPD.consistent with the heavy symptom burden and low treatment adherence reported in the Chinese COPD population[3, 14]. Poor symptom control may be related to poor adherence to inhaled medication. Overall 36.88% of patients had low adherence, and the degree of "unintentional"non-adherence was significantly higher than that of"intentional" non-adherence. This is consistent with the fact that most patients with COPD are elderly, with generally declining cognitive abilities,which may lead to frequent instances of forgetting to take their medication[15]. In the TAI questionnaire, Item 3 ("Do you stop using your inhaler when you feel well?") received the lowest score, reflecting patients' insufficient understanding of the chronic, progressive nature of the disease and their misconception that symptom relief equates to cure.

In this study, 95.74% of patients reported high satisfaction with their inhalers,which may reflect the continued design improvements and increased ease of use of currently available inhalation devices consistent with the results reported by Meng Weiwei et al[16]. However, objective assessments of inhaler

operation revealed that only 20.00% of patients were proficient in using their devices.This striking discrepancy between high subjective satisfaction (95.74%) and poor objective technical proficiency (80.00% with operational errors) suggests that patients frequently overestimate their inhaler skills, assuming that long-term use equates to correct use[17–19].Similar observational studies globally have confirmed that self-reported adherence and satisfaction rarely correlate with actual observed inhalation technique[20–23]. We describe this as a “fit gap”-a conceptual discrepancy between patients’ perceived and actual inhaler use—which fundamentally reflects the current emphasis on drug selection over inhalation technique training in clinical management.Indeed, many patients reported that they had not received standardized inhalation technique training from their first use of the device until the time of the survey[24–26].It should be emphasized that this “fit gap” is a conceptual interpretation of the observed discrepancy rather than a directly measured outcome, and the association between satisfaction and objectively measured technique was not statistically significant in the small combined subgroup (n = 30).

In addition to behavioral errors, the physical capability to generate adequate inspiratory flow is a prerequisite for the efficacy of DPIs[27–29]. In the present study, 68.18% of the 44 patients tested had a MEPIF below the standard threshold.Suboptimal PIF can lead to increased drug deposition in the oropharynx rather than the lower airways[30–31].Recent clinical evidence has linked suboptimal PIF in patients with COPD to an increased risk of severe exacerbations, accelerated disease progression, and higher readmission rates;however,these associations were derived from larger cohorts and require confirmation in prospective studies[32–36]. The inspiratory-capacity results in the present study should be interpreted cautiously given the small sample size and the need to clarify device-specific PIF thresholds.

To help bridge this discrepancy in routine primary care, general practitioners and clinical pharmacists may need to shift from passive prescription toward active device management. Incorporating the "teach-back" method—where patients physically demonstrate their inhaler technique during consultations—has been shown to reduce critical errors[37–40].In addition, regular screening of patients' PIF using respiratory trainers or digital assessment tools can guide the rational selection of devices (e.g. switching from DPIs to pMDIs with spacers or soft mist inhalers for patients with low PIF)[41–44].In the future, the integration of smart digital inhalers could provide real-time feedback on adherence and inhalation profiles, offering a potential strategy for precision management of COPD[45–49].These suggestions, however, warrant validation in prospective and interventional studies.

This study has several limitations. First, it employed a single-center cross-sectional design with a relatively small sample, which may introduce geographical and selection biases and limit generalizability. Second, no formal a priori sample size calculation was performed; although the full cohort provided adequate power for the main correlation between satisfaction and adherence, Too many restrictions on lung function testing for patients the objective-assessment subgroups (n = 65 and n = 44) and, in particular, the combined-analysis subgroup (n = 30) were small and substantially underpowered, and these subgroups only partially overlapped with the questionnaire cohort. Third, the locally developed inhalation technique assessment form has not yet undergone formal inter-rater reliability testing. Fourth,

the cross-sectional design cannot establish causal relationships, and the direction of the association between satisfaction and adherence remains to be determined. Finally, adherence and satisfaction were self-reported, which is subject to recall and social-desirability bias.

Conclusion

In summary, this exploratory study assessed symptom burden, adherence, satisfaction, inhaler technique, and inspiratory capacity among patients with COPD. Through three complementary sub-surveys, the study characterized the practical challenges of inhalation therapy from the perspectives of patients' subjective experience, operational behavior, and physiological capacity. Although the samples across the three sub-surveys did not fully overlap, they all derived from the same target population. The findings point to a substantial discrepancy between patients' high subjective satisfaction and their objectively assessed inhaler proficiency and inspiratory performance—a "fit gap" that warrants attention. These results are hypothesis-generating and suggest that, in clinical practice, general practitioners and pharmacists should not rely solely on patients' subjective satisfaction; incorporating objective assessments of inhaler proficiency and screening of inspiratory capacity into routine follow-up may help identify patients at risk of ineffective drug delivery. Confirmatory evidence from larger, prospective, multicenter studies is needed before definitive clinical recommendations can be made.

Abbreviations

COPD
Chronic Obstructive Pulmonary Disease
CAT
COPD Assessment Test
TAI
Test of Adherence to Inhalers
FSI–10
Feeling of Satisfaction with Inhaler-10
PIF
Peak Inspiratory Flow
EIT
Effective Inhalation Time
DPIs
Dry Powder Inhalers
pMDIs
pressurized Metered-Dose Inhalers
GOLD
Global Initiative for Chronic Obstructive Lung Disease
MEPIF
Minimum Effective PIF

Declarations

Ethics approval and consent to participate

This study has been approved by the Ethics Committee of the First Affiliated Hospital of Shihezi University (Approval No.: KJ2025-045-01) . Written informed consent was obtained from all participants prior to enrollment.The study was conducted in accordance with the provisions of the Declaration of Helsinki.

Consent for publication

All authors read and approved the final manuscript.

Availability of data and materials

All data generated or analysed during this study are included in this published article [and its supplementary information files]

Competing interests

The authors report no conflicts of interest in this work.

Funding

This study was supported by the [National Science and Technology Major Project SQ2025AAA030466].

Authors' contributions

Zikang Jin & Ziyue Yang:Conceptualization, Methodology, Data collection,Writing-original draft.

Baersi Ba:Validation, Methodology,Review and editing

Xingyao Wu: Investigation, Data collection.

Wen Wei:Quality Supervision and Control

Xiaoyi Wang: Conceptualization, Supervision, Project administration, Writing,review and editing.

Wanyu Li:Supervision, project management, writing, reviewing, editing, and financial support.

Acknowledgments

We acknowledge the assistance provided by the staff of the Medical Records Management Department and Pharmacy Department at the First Affiliated Hospital of Shihezi University during data collection.

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Figures

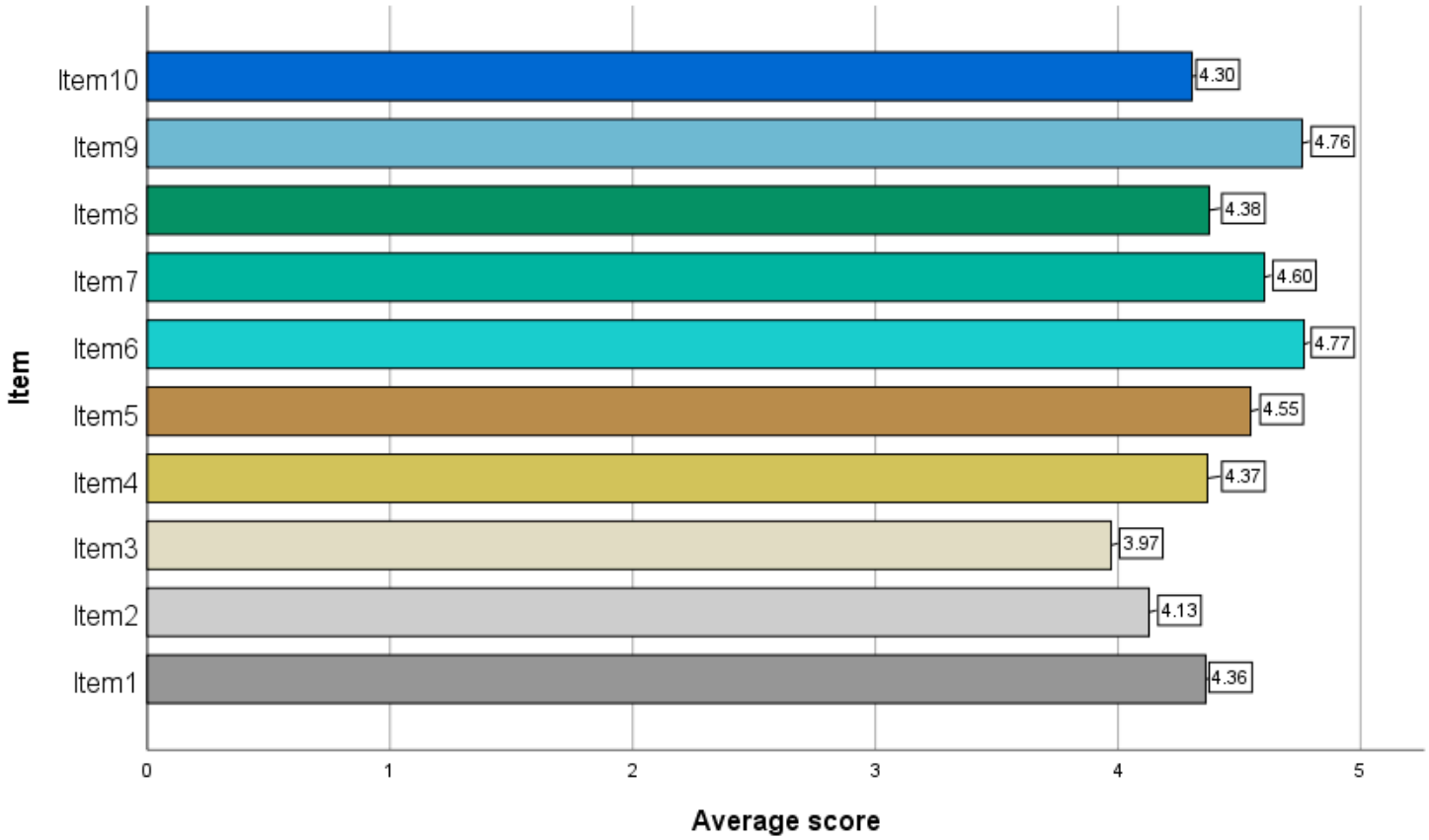


Figure 1

Average score for each item on the TAI

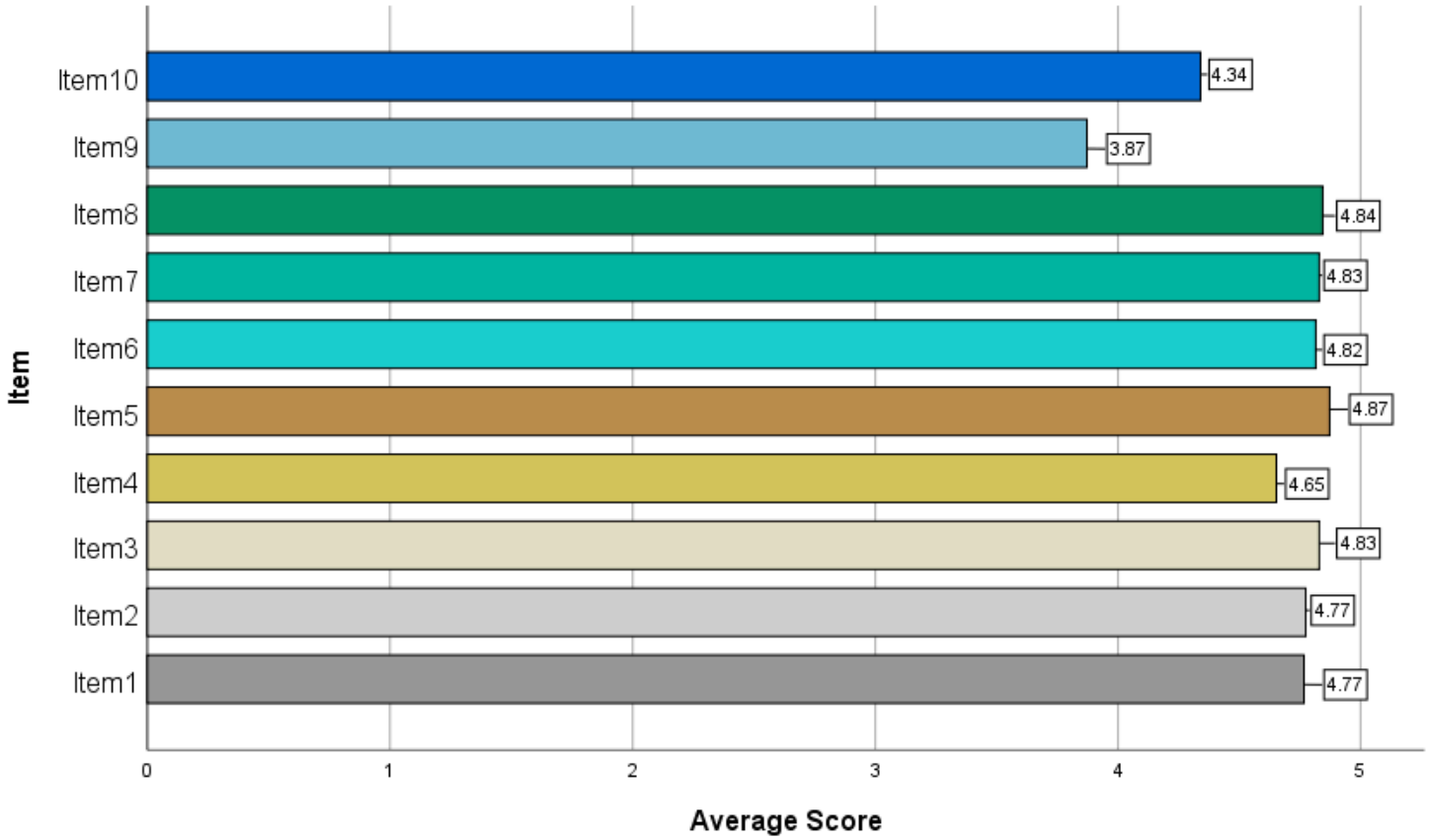


Figure 2

Average score for each item on the FSI-10

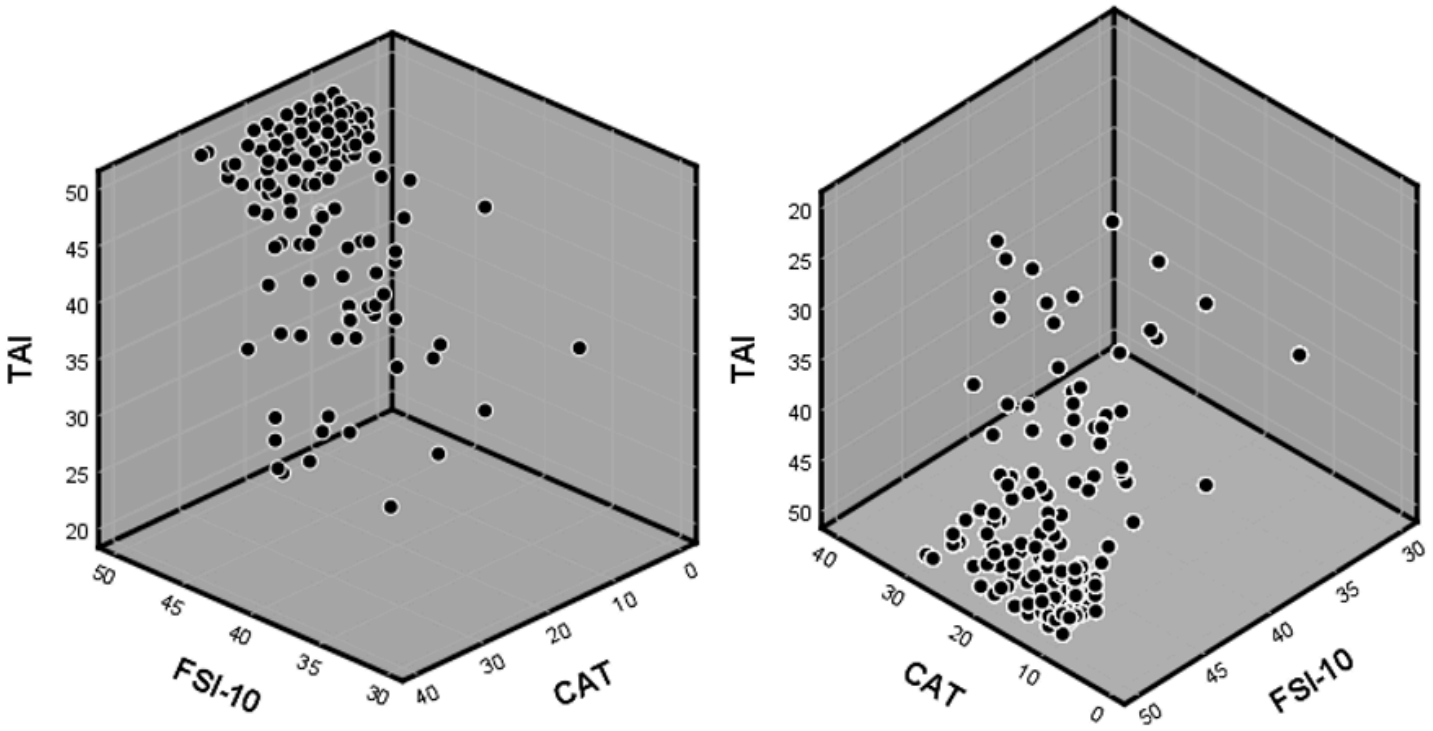


Figure 3

CAT, TAI, FSI-10, 3D scatter plot

Supplementary Files

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- Appendix14.docx