

Original Research Article

Comparison of inhaler technique errors among asthma patients using two different dry powder inhaler devices before and after pharmacist demonstration

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ABSTRACT

Background: Asthma is a chronic inflammatory airway disease requiring long-term management, with inhalation therapy as the cornerstone of treatment. Incorrect inhaler technique is common and contributes to poor disease control and reduced therapeutic efficacy. Patient education plays an important role in improving inhaler use and treatment outcomes. This study evaluated and compared inhaler technique, error patterns, and improvement following pharmacist demonstration among asthma patients using Revolizer and Lupihaler dry powder inhalers.

Methods: A prospective comparative observational study was conducted in a tertiary care hospital among 302 asthma patients, with 151 patients each using Revolizer and Lupihaler devices. Inhaler technique was assessed at three visits and categorized as good, needing improvement, or poor. Errors in key inhalation steps were documented, and structured pharmacist-led education was provided during follow-up. Data were analyzed using descriptive statistics.

Results: At baseline, good inhaler technique was observed in 31 (20.52%) Revolizer users and 26 (17.21%) Lupihaler users, increasing to 131 (86.75%) and 120 (79.47%) by visit 3. Poor technique declined from 67 (44.37%) to 2 (1.32%) in the Revolizer group and from 54 (36.76%) to 5 (3.31%) in the Lupihaler group. Errors in exhaling fully, inhalation, breath holding, and checking remaining powder decreased in both groups following education, with greater reductions observed among Revolizer users.

Conclusions: Structured pharmacist-led education significantly improved inhaler technique and reduced errors with both dry powder inhalers, with slightly greater improvement observed among Revolizer users. Regular assessment and repeated inhaler education should be incorporated into routine asthma care to optimize treatment outcomes.

Keywords: Administration, Inhalation, Asthma, Patient education as topic, Powder inhalers, Treatment outcome

INTRODUCTION

Asthma is a chronic inflammatory airway disease affecting millions of individuals worldwide and remains a major cause of morbidity, reduced quality of life, and increased healthcare burden. Poorly controlled asthma is associated with frequent exacerbations, hospital admissions, and increased healthcare utilization, emphasizing the need for effective long-term management strategies.¹ Inhalation

therapy is considered the cornerstone of asthma management, as it enables direct delivery of medication to the lungs, ensuring rapid therapeutic action with minimal systemic side effects. Dry powder inhalers (DPIs) are commonly used due to their breath-actuated mechanism and ease of use compared to other inhalation devices.²

The effectiveness of inhalation therapy, however, largely depends on the patient's ability to use the inhaler correctly,

and improper technique can significantly reduce drug deposition in the lungs. Studies have reported that incorrect inhaler technique is highly prevalent among asthma patients, with a majority committing at least one critical error during use.³ Such errors compromise therapeutic efficacy and contribute to poor disease control and unfavorable clinical outcomes.⁴

Common errors associated with DPI use include failure to exhale fully before inhalation, inadequate inspiratory effort, improper device handling, and failure to hold breath after inhalation, all of which reduce effective drug delivery.⁵

These inhalation errors are clinically significant, as they are associated with increased asthma symptoms, frequent exacerbations, and overall poor disease control, thereby increasing the burden on healthcare systems.⁶ In addition, incorrect inhaler technique is linked to reduced adherence to therapy, further worsening treatment outcomes and increasing disease severity.⁷ Educational interventions, including patient counseling and demonstration of inhaler use, have been shown to significantly improve inhaler technique and reduce error rates.³ Repeated education and reinforcement during follow-up visits further enhance patient performance and sustain improvements over time.⁸

Healthcare professional-led interventions, particularly by pharmacists and clinicians, have proven effective in improving inhaler technique and optimizing asthma control among patients.⁹ Additionally, innovative approaches such as video-assisted education have demonstrated comparable effectiveness to traditional face-to-face training in improving inhaler technique.¹⁰ Despite these interventions, inhaler technique may deteriorate over time without regular reassessment and reinforcement, highlighting the importance of continuous monitoring in clinical practice.⁴

Furthermore, different DPI devices vary in their design and ease of use, which can influence patient performance and the frequency of inhalation errors.¹¹ Comparative evaluation of inhaler devices is therefore essential to identify device-specific advantages and improve patient outcomes in asthma management.¹² However, studies directly comparing inhaler technique, error patterns, and improvement following patient education between different DPI devices remain limited. Therefore, this study aims to evaluate and compare inhaler technique, error patterns, and clinical characteristics among bronchial asthma patients using Revolizer and Lupihaler dry powder inhalers, and to assess improvement following patient education over successive visits.

METHODS

Study design and setting

This prospective, comparative observational study was conducted at Sudha Hospitals, a multispecialty tertiary

care hospital in Erode, Tamil Nadu, India, from September 2025 to February 2026. The study evaluated and compared inhaler technique, error patterns, and clinical characteristics among patients using Revolizer and Lupihaler dry powder inhalers.

Study population

A total of 302 patients diagnosed with bronchial asthma were included in the study, with 151 patients in each group based on the inhaler device used.

Inclusion criteria

Patients diagnosed with bronchial asthma, prescribed either Revolizer or Lupihaler, and willing to participate with availability for follow-up visits were included in the study.

Exclusion criteria

Patients with severe comorbid conditions affecting inhalation ability, those unable to perform inhalation technique assessment, and those who were lost to follow-up were excluded from the study.

Data collection and variables

Data were collected using a structured data collection form, including demographic details such as age and gender, social habits including smoking and alcohol consumption, clinical characteristics such as duration of asthma and comorbidities, and treatment-related details including type of drug and dosing frequency.

Assessment of inhaler technique and errors

Patients' inhaler technique was assessed at three visits (visit 1, visit 2, and visit 3) and categorized as good, needing improvement, or poor. Specific inhalation steps including exhaling fully, inhaling deeply, holding breath, and checking powder were evaluated to identify errors, which were recorded at baseline and final visits.

Intervention and follow-up

During follow-up visits, patients were provided with education and demonstration on correct inhaler technique to improve their performance over time.

Outcome measures and statistical analysis

The primary outcomes included improvement in inhaler technique and reduction in inhalation errors over successive visits, along with comparison between the two inhaler devices.

Data were analyzed using descriptive statistics and expressed as frequency and percentage.

RESULTS

In the Revolizer group, participants were distributed as follows: ≤18 years 0 (0.00%), 19-30 years 14 (9.00%), 31-45 years 39 (25.80%), 46-60 years 47 (31.10%), and ≥61 years 51 (33.80%). In the Lupihaler group, the distribution was ≤18 years 2 (1.32%), 19-30 years 22 (14.57%), 31-45 years 43 (28.48%), 46-60 years 35 (23.18%), and ≥61 years 49 (32.45%). Gender distribution showed 78 males (51.66%) and 73 females (48.34%) in the Revolizer group, and 79 males (52.32%) and 72 females (47.68%) in the Lupihaler group (Table 1).

Table 1: Baseline demographic characteristics.

Variables	Category	Revolizer, N (%)	Lupihaler, N (%)
Age (years)	≤18	0 (0.00)	2 (1.32)
	19-30	14 (9.00)	22 (14.57)
	31-45	39 (25.80)	43 (28.48)
	46-60	47 (31.10)	35 (23.18)
	≥61	51 (33.80)	49 (32.45)
Gender	Male	78 (51.66)	79 (52.32)
	Female	73 (48.34)	72 (47.68)

In the Revolizer group, social habits included non-smoker and alcoholic 3 (2.00%), non-smoker and non-alcoholic 100 (66.00%), smoker and alcoholic 23 (15.00%), and smoker and non-alcoholic 25 (17.00%), while in the Lupihaler group they were 2 (1.32%), 91 (60.26%), 27 (17.89%), and 31 (20.53%) respectively. Duration of asthma in the Revolizer group was <1 year in 50 (33.11%), 1-5 years in 83 (54.97%), and >5 years in 18 (11.92%), whereas in the Lupihaler group it was <1 year in 50 (33.11%), 1-5 years in 84 (55.63%), and >5 years in 17 (11.26%) (Table 2).

Table 2: Social habits and clinical characteristics.

Variables	Category	Revolizer, N (%)	Lupihaler, N (%)
Social habits	Non-smoker and alcoholic	3 (2.00)	2 (1.32)
	Non-smoker and non-alcoholic	100 (66.00)	91 (60.26)
	Smoker and alcoholic	23 (15.00)	27 (17.89)
	Smoker and non-alcoholic	25 (17.00)	31 (20.53)
Duration of asthma (years)	<1	50 (33.11)	50 (33.11)
	1-5	83 (54.97)	84 (55.63)
	>5	18 (11.92)	17 (11.26)

In the Revolizer group, comorbidities included HTN 34 (22.51%), DM 29 (19.21%), CKD 2 (1.32%), HTN + DM 12 (7.95%), thyroid disorder 7 (4.64%), migraine 3

(1.99%), others 7 (4.63%), and nil in 57 (37.75%). In the Lupihaler group, HTN was observed in 30 (19.87%), DM in 21 (13.91%), CKD in 8 (5.30%), HTN + DM in 16 (10.60%), thyroid disorder in 1 (0.66%), migraine in 9 (5.96%), others in 14 (9.27%), and nil in 55 (36.42%), with a total of 151 participants in each group (100%) (Table 3).

Table 3: Comorbidities distribution.

Comorbidities	Revolizer, N (%)	Lupihaler, N (%)
HTN	34 (22.51)	30 (19.87)
DM	29 (19.21)	21 (13.91)
CKD	2 (1.32)	8 (5.30)
HTN + DM	12 (7.95)	16 (10.60)
Thyroid disorder	7 (4.64)	1 (0.66)
Migraine	3 (1.99)	9 (5.96)
Others	7 (4.63)	14 (9.27)
Nil	57 (37.75)	55 (36.42)
Total	151 (100)	151 (100)

In the Revolizer group, Budesonide was used in 37 (24.50%) and Budesonide + Formoterol in 114 (75.50%), while in the Lupihaler group, Budesonide was used in 34 (22.52%) and Budesonide + Formoterol in 117 (77.48%). Regarding frequency, OD was observed in 37 (24.50%) and BD in 114 (75.50%) in the Revolizer group, whereas in the Lupihaler group, OD was seen in 42 (27.81%) and BD in 109 (72.19%) (Table 4).

Table 4: Drug therapy and frequency.

Variables	Category	Revolizer, N (%)	Lupihaler, N (%)
Drug	Budesonide	37 (24.50)	34 (22.52)
	Budesonide + Formoterol	114 (75.50)	117 (77.48)
Frequency	OD	37 (24.50)	42 (27.81)
	BD	114 (75.50)	109 (72.19)

At visit 1, in the Revolizer group, good technique was observed in 31 (20.52%), need improvement in 53 (35.09%), and poor in 67 (44.37%), while in the Lupihaler group, good was 26 (17.21%), need improvement 71 (47.01%), and poor 54 (36.76%). At visit 2, good technique increased to 79 (52.31%), need improvement was 65 (43.04%), and poor reduced to 7 (4.63%) in the Revolizer group, whereas in the Lupihaler group, good was 60 (39.73%), need improvement 75 (49.66%), and poor 16 (10.59%).

At visit 3, good technique further improved to 131 (86.75%), need improvement was 18 (11.92%), and poor 2 (1.32%) in the Revolizer group, while in the Lupihaler group, good was 120 (79.47%), need improvement 26 (17.21%), and poor 5 (3.31%) (Table 5).

Error rates decreased from visit 1 to visit 3 in both groups. In the Revolizer group, errors in exhaling fully reduced from 97 (64.23%) to 26 (17.21%), inhaling deeply from 105 (69.53%) to 24 (15.89%), holding breath from 121 (80.13%) to 43 (28.47%), and checking powder from 62 (40.52%) to 5 (3.31%). In the Lupihaler group, errors in exhaling fully decreased from 123 (81.5%) to 42 (27.8%), inhaling deeply from 123 (82.8%) to 56 (37.1%), holding breath from 125 (82.8%) to 62 (41.1%), and checking powder from 85 (56.3%) to 32 (21.2%) (Table 6).

Table 5: Inhaler technique.

Visits	Technique	Revolizer, N (%)	Lupihaler, N (%)
Visit 1	Good	31 (20.52)	26 (17.21)
	Need improvement	53 (35.09)	71 (47.01)
	Poor	67 (44.37)	54 (36.76)
Visit 2	Good	79 (52.31)	60 (39.73)
	Need improvement	65 (43.04)	75 (49.66)
	Poor	7 (4.63)	16 (10.59)
Visit 3	Good	131 (86.75)	120 (79.47)
	Need improvement	18 (11.92)	26 (17.21)
	Poor	2 (1.32)	5 (3.31)

Table 6: Error comparison.

Steps	Revolizer V1, N (%)	Revolizer V3, N (%)	Lupihaler V1, N (%)	Lupihaler V3, N (%)
Exhale fully	97 (64.23)	26 (17.21)	123 (81.5)	42 (27.8)
Inhale deep	105 (69.53)	24 (15.89)	123 (82.8)	56 (37.1)
Hold breath	121 (80.13)	43 (28.47)	125 (82.8)	62 (41.1)
Check powder	62 (40.52)	5 (3.31)	85 (56.3)	32 (21.2)

DISCUSSION

In our study, participants aged ≥ 61 years constituted 51 (33.80%) in the Revolizer group and 49 (32.45%) in the Lupihaler group, while males accounted for 78 (51.66%) and 79 (52.32%) respectively. Akhoon et al reported that patients aged >50 years formed the majority, with males comprising nearly 56% of participants.¹³ Woo et al demonstrated that elderly asthmatic patients commonly experienced inhaler handling difficulties, while Price et al observed inhalation errors in $>70\%$ of elderly asthma patients.^{14,15} These findings indicate that elderly patients remain particularly vulnerable to incorrect inhaler use. Advanced age and male predominance may therefore contribute to poor inhaler handling and suboptimal asthma control. Repeated inhaler education may be especially beneficial in older populations.

Non-smokers and non-alcoholics predominated in our study, accounting for 100 (66.00%) and 91 (60.26%) participants respectively, while asthma duration of 1-5 years was observed in 83 (54.97%) and 84 (55.63%) participants. Bosnic-Anticevich et al reported that $>80\%$ of asthma patients committed at least one inhaler error irrespective of disease duration.⁴ Lavorini et al demonstrated incorrect DPI use in nearly 50-80% of asthma and COPD patients, while Sanchis et al confirmed that inhaler misuse remains highly prevalent despite prolonged therapy.^{2,5} These observations suggest that inhaler misuse persists despite prolonged treatment duration. Duration of therapy alone may not ensure proper inhaler technique. Continuous reinforcement and periodic reassessment are therefore essential.

Hypertension was present in 34 (22.51%) and 30 (19.87%) participants, while diabetes mellitus was observed in 29 (19.21%) and 21 (13.91%) participants in the Revolizer and Lupihaler groups respectively. Woo et al reported that hypertension and diabetes adversely influenced asthma control and inhaler handling.¹⁴ Roche et al associated inhalation errors with poorer asthma outcomes and increased healthcare utilization.¹⁶ Shlomi et al demonstrated that comorbidities negatively affected inhaler adherence and performance.¹⁷ The coexistence of chronic comorbidities may complicate effective asthma management and inhaler use. Patients with multiple illnesses may require closer monitoring and individualized counselling. Proper management of comorbid conditions may improve overall treatment adherence and disease control.

Budesonide + Formoterol therapy was predominantly prescribed in both groups [114 (75.50%) and 117 (77.48%)], with twice-daily dosing observed in 114 (75.50%) and 109 (72.19%) participants respectively. Gálffy et al demonstrated improved asthma control and patient satisfaction with Budesonide/Formoterol therapy.¹⁸ Rabin et al reported poorer outcomes following inhaler switching among 260,268 patients.¹⁹ Woo et al showed that repeated inhaler education improved adherence and inhaler technique among ICS-LABA users.¹⁴ These findings support the effectiveness of Budesonide/Formoterol therapy in long-term asthma management. Consistent inhaler use together with repeated counselling may enhance adherence and therapeutic outcomes. Avoiding unnecessary inhaler switching may further improve patient confidence and disease control.

Good inhaler technique improved from 31 (20.52%) to 131 (86.75%) in the Revolizer group and from 26 (17.21%) to 120 (79.47%) in the Lupihaler group, while poor technique reduced from 67 (44.37%) to 2 (1.32%) and from 54 (36.76%) to 5 (3.31%) respectively. Price et al, Bosnic-Anticevich et al, and Woo et al similarly demonstrated significant improvement in inhaler mastery following repeated counselling and follow-up.^{4,14,15} The marked improvement observed highlights the effectiveness of

repeated inhaler training and assessment. Structured counselling significantly reduces incorrect inhaler practices and improves technique retention. Regular follow-up sessions may therefore play a vital role in achieving optimal asthma management.

In the Revolizer group, errors in exhaling fully reduced from 97 (64.23%) to 26 (17.21%), inhaling deeply from 105 (69.53%) to 24 (15.89%), breath holding from 121 (80.13%) to 43 (28.47%), and checking powder from 62 (40.52%) to 5 (3.31%). In the Lupihaler group, corresponding reductions were from 123 (81.5%) to 42 (27.8%), 123 (82.8%) to 56 (37.1%), 125 (82.8%) to 62 (41.1%), and 85 (56.3%) to 32 (21.2%) respectively. Sanchis et al identified inadequate exhalation, insufficient inspiratory effort, and failure to hold breath as common critical inhaler errors.¹⁵ Lavorini et al demonstrated that incorrect DPI manoeuvres reduce effective drug delivery, while Price et al reported that repeated inhaler education significantly reduced critical inhalation errors and improved long-term inhaler technique retention.^{2,15}

These findings emphasize the importance of targeted inhaler education in reducing critical inhaler errors. Correcting procedural mistakes may significantly improve effective drug delivery and therapeutic response. Repeated demonstration and patient re-evaluation are therefore crucial for long-term inhaler technique maintenance.

Limitations

This study was conducted in a single tertiary care center, which may limit generalizability. The short follow-up period may not reflect long-term retention of inhaler technique. Additionally, observational assessment of technique may introduce minor observer bias.

CONCLUSION

Inhaler technique among bronchial asthma patients is frequently inadequate at baseline but improves significantly with structured patient education and repeated demonstration. Both Revolizer and Lupihaler devices showed substantial reduction in inhalation errors over successive visits, with slightly greater improvement observed in the Revolizer group. These findings emphasize that inhaler technique is a modifiable factor and highlight the essential role of continuous education, regular follow-up, and reinforcement by healthcare professionals in achieving optimal asthma control. Incorporating routine inhaler technique assessment into clinical practice can significantly enhance therapeutic outcomes, reduce exacerbations, and improve overall quality of life in asthma patients.

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