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Comparison of Inhaler Technique between Dry Powder Inhalers and Metered Dose Inhalers among adults with Obstructive Airway Disease

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ABSTRACT

Background: Proper inhaler technique is crucial for effective management of obstructive airway diseases, yet many patients misuse it. Dry powder inhalers (DPI) and metered dose inhalers (MDI) require different handling skills, and errors in technique can lead to poor drug delivery and suboptimal disease control. Understanding the prevalence and types of errors can guide targeted patient education and improve outcomes.

Objective: To assess and compare inhaler technique performance among adult patients using dry powder inhalers (DPI) and metered dose inhalers (MDI), and to determine the prevalence of specific technique errors along with associated patient-related factors.

Methodology: This hospital-based cross-sectional study was conducted in the Department of Pulmonology, Mardan Medical Complex, Mardan from July 2023 to July 2024. Adult patients with asthma or COPD who had used DPI or MDI for at least 3 months were enrolled in this study.

Results: A total of 180 patients (90 DPI, 90 MDI) with a mean age of 58.6 ± 12.4 years were included, of whom 54.4% were female. Inhaler technique errors were highly prevalent, observed in 91.1% of DPI users and 94.4% of MDI users before instruction. Age was significantly associated with errors among MDI users, with an 8% increase in error probability per year (OR 1.08; 95% CI: 1.03–1.14).

Conclusion: Inhaler technique errors are highly prevalent among adults with obstructive airway disease using both DPI and MDI, with breathing-related and device-specific errors most common. Older age was associated with higher error rates in MDI users, highlighting the need for tailored interventions.

Keywords: Respiratory Diseases; Obstructive Airway Diseases; Inhaler; Inhaler techniques

Introduction

Obstructive airway diseases, particularly asthma and chronic obstructive pulmonary disease (COPD), represent a significant global health burden and are among the leading causes of morbidity and healthcare utilization worldwide. According to recent estimates, asthma affects more than 260 million people globally, while COPD is projected to become the third leading cause of death worldwide.[1,2] Inhaled pharmacotherapy remains the cornerstone of management for both conditions, as it allows targeted drug delivery to the airways, rapid onset of action, and reduced systemic adverse effects compared with oral or parenteral therapy.[3]

Despite advances in inhaler technology and pharmacologic formulations, the effectiveness of inhaled therapy is critically dependent on correct inhaler technique. International guidelines, including those from the Global Initiative for Asthma (GINA) and the Global Initiative for Chronic Obstructive Lung Disease (GOLD), consistently emphasize that incorrect inhaler technique is a significant cause of poor disease control, frequent exacerbations, and increased healthcare costs.[1,2] Studies have demonstrated that even slight deviations from correct technique can significantly reduce lung drug deposition, resulting in suboptimal therapeutic benefit.[4]

A wide range of inhaler devices is currently available, with dry powder inhalers (DPIs) and metered dose inhalers (MDIs) being the most commonly prescribed. These devices differ substantially in their operational mechanisms and the techniques required. DPIs require adequate inspiratory flow and correct breathing tricks, whereas MDIs require precise coordination between inhalation and device actuation, along with proper device preparation such as shaking and timing.[5] These differences may influence error patterns, patient preference, and overall treatment effectiveness.

Numerous studies across different regions have reported high rates of inhaler misuse, with error prevalence ranging from 50% to over 90%, depending on device type, assessment method, and patient population.[6-8] Significantly, inhaler technique errors have been associated with poor symptom control, increased risk of exacerbations, reduced quality of life, and higher healthcare utilization.[9] Although inhaler education has been shown to improve technique, errors often persist, and skill retention declines over time without reinforcement.[10]

In low- and middle-income countries, including Pakistan, additional challenges, such as limited patient education, time constraints during clinical encounters, and variability in healthcare providers' training, may further contribute to poor inhaler technique.[11] While several studies have evaluated inhaler technique in asthma or COPD patients, comparative data examining specific error patterns between DPI and MDI users, as well as the factors associated with these errors, remain limited, particularly in adult populations attending routine clinical care.[4-6]

Given the high burden of obstructive airway diseases, the widespread use of inhaler devices, and the well-established impact of incorrect inhaler technique on clinical outcomes, there is a clear need to evaluate inhaler technique in real-world settings systematically. Understanding the prevalence, nature, and determinants of inhaler technique errors, as well as differences between DPI and MDI users, is essential for designing targeted educational interventions and optimizing device selection. Therefore, this study was conducted to compare inhaler technique performance between dry powder inhalers and metered dose inhalers among adults with obstructive airway disease, to identify common technique errors, and to explore patient-related factors associated with incorrect inhaler use.

Objective

To assess and compare inhaler technique performance among adult patients using dry powder inhalers (DPI) and metered dose inhalers (MDI), and to determine the prevalence of specific technique errors along with associated patient-related factors.

Methodology

This was a hospital-based cross-sectional analytical study conducted in the Department of Pulmonology at Mardan Medical Complex from July 2023 to July 2024. The pulmonology outpatient department (OPD) serves a large number of adult patients with asthma and chronic obstructive pulmonary disease (COPD). Adult patients attending the OPD during the study period were screened for eligibility. Patients diagnosed with obstructive airway disease, including asthma and COPD, and who were prescribed either a dry powder inhaler (DPI) or a metered dose inhaler (MDI) as part of their maintenance therapy were considered for inclusion.

A total of 180 participants were enrolled using non-probability consecutive sampling, comprising 90 DPI users and 90 MDI users. The sample size was considered adequate based on previous studies reporting high prevalence of inhaler technique errors and feasibility within the study period (Figure 1).

Patients aged 18 years or older with a clinical diagnosis of asthma or chronic obstructive pulmonary disease (COPD) by the treating pulmonologist were eligible for inclusion. Participants were required to have been using either a dry powder inhaler (DPI) or a metered dose inhaler (MDI) regularly for at least three months and be able to demonstrate their inhaler technique independently. Only those willing to provide informed consent were enrolled in the study. Patients were excluded if they had severe cognitive impairment or psychiatric illnesses affecting comprehension, neuromuscular disorders or physical disabilities limiting inhaler use, or were experiencing an acute exacerbation requiring emergency management at presentation. Additionally, individuals using only nebulized therapy or those unable or unwilling to provide informed consent were not included.

After obtaining written informed consent, participants' demographic and clinical data were recorded using a structured data collection proforma. Information collected included age, sex, diagnosis, smoking status, duration of disease, duration of inhaler use, type of inhaler device, and history of prior inhaler technique education. Each participant was then asked to demonstrate their inhaler technique using their prescribed inhaler device as they usually do at home. Demonstrations were observed directly by a trained investigator without interruption or correction during the initial assessment.

Inhaler technique was evaluated using standardized, step-by-step checklists developed from manufacturer instructions and international guideline recommendations, with separate validated checklists for dry powder inhalers (DPI) and metered-dose inhalers (MDI). Each step of the inhaler procedure was marked as either correctly or incorrectly performed, and the presence of one or more incorrectly performed steps was considered indicative of incorrect inhaler technique. Following the initial assessment, all participants received a standardized education session on correct inhaler use, which included a verbal explanation of the proper steps, a physical demonstration by the investigator, and special emphasis on critical steps such as complete exhalation, inhalation maneuver, breath holding, and device preparation. Participants were then asked to re-demonstrate their inhaler technique, and a post-instruction assessment was conducted using the same checklist to evaluate immediate improvement.

The primary outcomes of the study were the prevalence of any inhaler technique errors among DPI and MDI users, the distribution of errors at each step of inhaler use, and the change in error prevalence following the educational intervention. Secondary outcomes included identification of patient-related factors associated with inhaler technique errors, such as age, sex, academic level, smoking status, diagnosis, and prior inhaler training.

Data were entered and analyzed using Statistical Package for Social Sciences (SPSS) version 26. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean ± standard deviation or median (interquartile range), as appropriate. Comparisons between the DPI and MDI groups were performed using the Chi-square test or Fisher's exact test for categorical variables, and the independent-samples t-test for continuous variables. Pre- and post-instruction comparisons were analyzed using McNemar's test. Logistic regression analysis was performed to identify factors associated with inhaler technique errors. Odds ratios (ORs) with 95% confidence intervals (CI) were calculated. A p-value < 0.05 was considered statistically significant.

The study protocol was reviewed and approved (Ref:201/01/23/MMC) by the Institutional Ethics Committee of Mardan Medical Complex. Written informed consent was obtained from all participants before enrollment. Confidentiality of patient information was maintained throughout the study, and participants were informed of their right to withdraw at any stage without affecting their medical care.

Results

A total of 180 adult patients with obstructive airway disease were included in this study. For study purposes, 90 patients included in to the Dry Powder Inhaler (DPI) group and 90 patients to the Metered Dose Inhaler (MDI) group. The mean age of participants was 58.6 ± 12.4 years, and the majority were female (54.4%). Bronchial asthma was the most common diagnosis overall (62.2%), followed by COPD (37.8%). Baseline demographic and clinical characteristics were comparable between the two groups (Table 1).

Table 1. Demographic and Clinical Characteristics of Participants (n = 180)

Variable	DPI (n=90)	MDI (n=90)	p-value
Age, mean ± SD (years)	59.2 ± 12.1	58.0 ± 12.7	0.48
Sex (Male), n (%)	38 (42.2%)	44 (48.9%)	0.37
Diagnosis – Asthma	54 (60.0%)	58 (64.4%)	0.54
Diagnosis – COPD	36 (40.0%)	32 (35.6%)	0.54
Smoking (ever), n (%)	34 (37.8%)	29 (32.2%)	0.42
Previous technique training, n (%)	62 (68.9%)	65 (72.2%)	0.61

Results showed that, before instruction, inhaler technique errors were very common in both groups. Among DPI users, 82 of 90 participants (91.1%) made at least one error, and among MDI users 85 of 90 (94.4%) did the same. After standardized instruction, both groups improved noticeably: the rate of any technique error fell to 52.2% (47/90) for DPI users and to 45.5% (41/90) for MDI users. The reductions after instruction were statistically significant for both devices ($p < 0.001$).

Participants with DPI made mistakes mostly in the respiration technique steps. The primary mistake was not exhaling completely before inhaling, which happened with 69 users (76.7%). Next, not holding the breath for 8-10 seconds after inhalation was pointed out in 48 users (53.3%), and inhalation technique being wrong, particularly not doing a deep and strong inhalation was noticed in 38 users (42.2%). It has been implied that wrong execution of the respiratory maneuver was the major factor leading to incorrect DPI usage (Table 2).

The errors in inhaler technique among MDI users were mainly due to improper maneuvers and incorrect device handling. In this group, the most common error was not exhaling completely before inhaling, which was observed in 72 participants (80.0%), followed by the wrong inhalation technique: simply not taking a slow, deep breath, noted in 55 participants (61.1%). There were also device preparation errors, and 33 participants (36.7%) did not shake the inhaler before using it. Moreover, the lack of coordination between actuation and inhalation, a critical step unique to MDI use, was observed in 21 participants (23.3%). The results of this study reveal how difficult it is for patients to use MDI properly and the frequent challenges they encounter in coordinating inhaler activation with effective inhalation (Table 3).

The logistic regression analysis identified age as the only factor significantly associated with errors in inhaler technique among MDI users. It was found that with each additional year, the probability of at least one error in the MDI technique increased by 8% (odds ratio [OR] 1.08; 95% confidence interval [CI]: 1.03–1.14). On the other hand, age did not have a significant impact on the inhaler technique errors made by DPI users. Besides, there were no associations between errors in inhaler technique and other patient-related factors, such as sex, educational attainment, smoking status, underlying diagnosis, or prior inhaler technique training, that were statistically significant for either inhaler type (Table 4).

Table 2. Prevalence of Errors at Each Step of DPI Technique (n = 90)

DPI Step	Error n (%)
Step 1 – Remove cover	0 (0%)
Step 2 – Prime device	3 (3.3%)
Step 3 – Correct positioning	7 (7.8%)
Step 4 – Full exhalation before use	69 (76.7%)
Step 5 – Good lip seal	12 (13.3%)
Step 6 – Deep, forceful inhalation	38 (42.2%)
Step 7 – Breath hold 8–10 sec	48 (53.3%)
Step 8 – Remove mouthpiece	6 (6.7%)
Step 9 – Slow exhalation	15 (16.7%)

Discussion

In the present study, 180 cases were included and it was observed that inhaler technique errors were very common among both dry powder inhaler (DPI) and metered dose inhaler (MDI) users. Results showed that, 91.1% of DPI and 94.4% of MDI users made at least one inhaler technique error. After standardized inhaler technique instruction, the prevalence of errors dropped dramatically to 52.2% for DPI users and 45.5% for MDI users ($p < 0.001$). Among the errors, incorrect breathing maneuvers were the most frequent; meanwhile, ageing was independently associated with the occurrence of inhaler technique errors among MDI users but not among DPI users.

The very high baseline prevalence of inhaler technique errors observed in our study is in line with the current literature. Usmani et al. conducted a big systematic

Table 3. Prevalence of Errors at Each Step of MDI Technique (n = 90)

MDI Step	Error n (%)
Step 1 – Remove cap	0 (0%)
Step 2 – Shake inhaler	33 (36.7%)
Step 3 – Full exhalation before use	72 (80.0%)
Step 4 – Proper positioning	9 (10.0%)
Step 5 – Coordination (actuation + inhalation)	21 (23.3%)
Step 6 – Slow, deep inhalation	55 (61.1%)
Step 7 – Breath hold	29 (32.2%)
Step 8 – Remove mouthpiece with slow exhalation	7 (7.8%)

review. They found that critical inhaler errors happen to 40-80% of the patients, depending on the type of device and the method of assessment, and alarming facts of these errors being so high have been recorded over the past two decades, during which no less emphasis was given on inhaler education through guidelines.[11] Likewise, a study covering many countries that included patients with asthma and COPD found that only 31% of patients had correct inhaler technique, independent of device type.[12] Our pre-instruction error rates, over 90% in both groups, closely match these results. Dalal et al. confirmed in their study that 88% of adult asthma patients were using MDIs incorrectly, with most errors occurring during exhalation and coordination.[13] The survey by Harb et al. also showed incorrect technique in 84% of DPI users and 91% of MDI users, providing evidence that our findings apply to low- and middle-income settings.[14]

One of the main discoveries of our research was a substantial reduction in inhaler technique errors after instruction; however, errors remained prevalent even after the educational process. This change aligns with the results of recent interventional studies. Scullion's research indicated that structured inhaler education could cut the number of critical errors by 35-50%, but complete error eradication was rare even after a single session.[15] A similar conclusion was drawn by a 2023 meta-analysis, which stated that inhaler education leads to significant improvement in technique. Still, misunderstandings occur within 2 to 6 months if no reinforcement is provided.[16] The persistence of errors post-instruction in our study highlights the need for evaluation and reinforcement rather than counselling. This is in accordance with the Global Initiative for Asthma (GINA) and GOLD guidelines, which recommend inhaler technique assessment at every patient visit.[1,17]

The users of DPI committed mainly errors: exhaling incompletely before taking the next breath (76.7%), not holding the breath long enough (53.3%), and not putting enough effort into inhaling (42.2%). Such results corroborate earlier studies showing that the success of DPI is incredibly reliant on correct inspiratory flow and breathing sequence. Sorino et al. found that errors during the inspiratory maneuver accounted for more than 60% of critical DPI errors and, consequently, reduced lung drug deposition.[18] The most common errors were related to breathing, which could indicate that patients did not fully comprehend the necessity of exhalation and breath-holding, or that the healthcare providers' demonstrations were impractical. In contrast to MDIs, DPIs use the patient's own power to draw in the drug, so the technique becomes particularly susceptible to elderly patients or those with severe airflow restriction.[19]

A study conducted by Price et al, observed that MDI users mainly did not exhale completely before inhalation (80.0%), inhaled slowly and deeply (61.1%), did not shake the inhaler (36.7%), and had poor coordination between actuation and inhalation (23.3%). The findings correlate well with several studies that have indicated that coordination and timing are the most significant barriers to using MDIs. Considerable research in Europe found that as much as 70% of MDI users could not match inhalation with actuation, so the drug delivery was less.[20] The mechanical sophistication of MDIs, especially the need for precise coordination, is probably the reason for higher error rates compared to DPIs. This further supports earlier suggestions that spacers or other devices should be used in patients with coordination problems.[21]

Our study revealed that age was the only significant factor associated with inhaler technique errors, and this association was observed only among MDI users. The

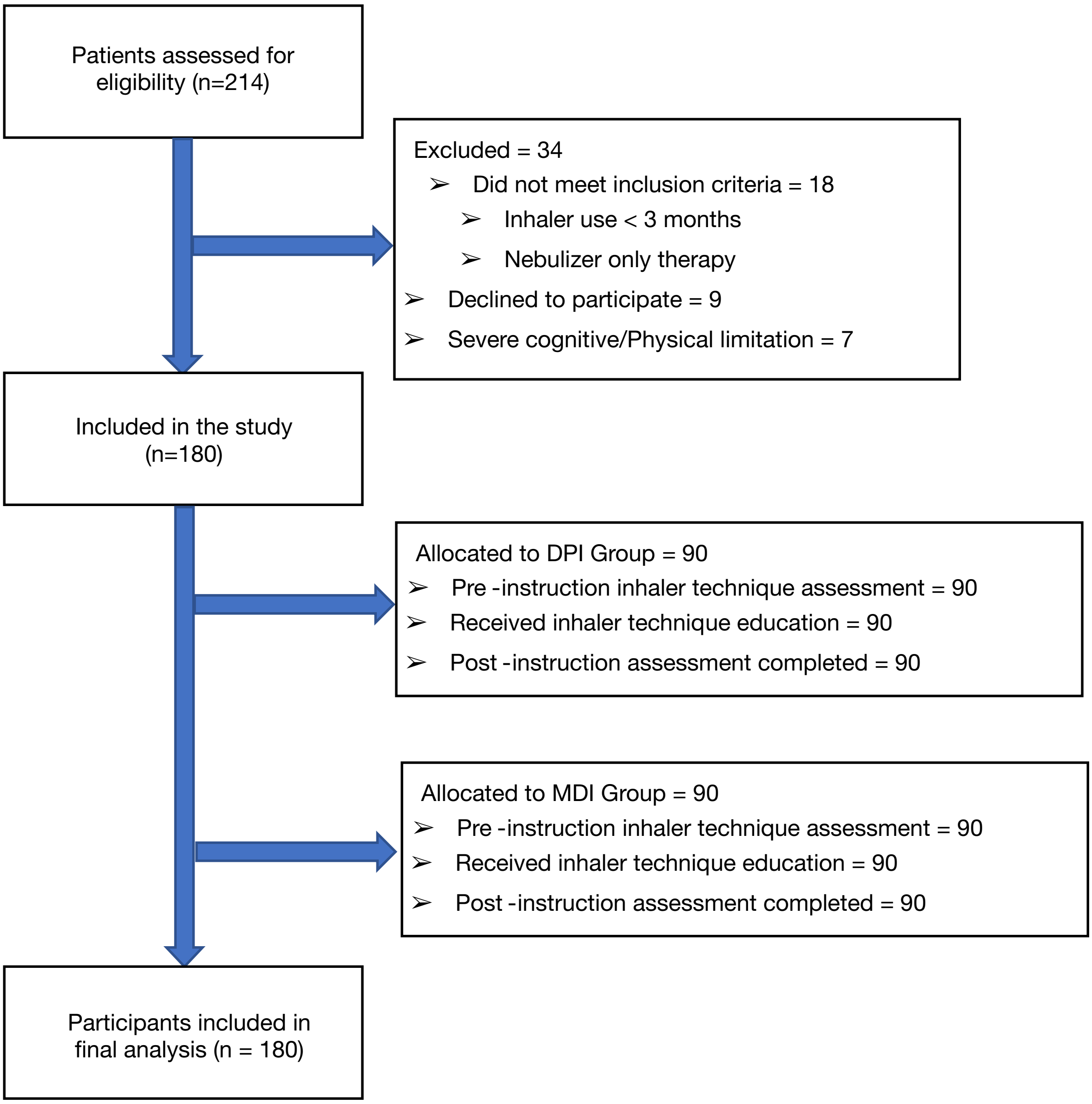

Figure 1. Flow diagram showing selection, allocation, and analysis of study participants

likelihood of a mistake with an MDI device increased by 8% for each additional year of age. This result agrees with studies indicating that older people are more likely to have difficulty using MDIs due to reduced motor coordination, cognitive abilities, and inhalation control.[22] On the other hand, age was not a factor in DPI errors, suggesting that the device's design may play an essential role in the success of the technique's application.

Inhaler technique errors were not found to be associated with sex, level of education, smoking habits, type of diagnosis, or previous training. These associations' absence is consistent with recent studies that reported similar results, indicating that self-reported prior training is not a reliable indicator of the technique being correct, especially in the absence of reinforcement or low-quality instruction.[23]

Improper inhaler techniques have been a significant reason for poor control of illness, more frequent exacerbations, higher health care costs, and less satisfaction with life.[11,24] The consequences of our study are the necessity of properly structured inhaler education programs, incorporated into routine medical care and involving not just doctors but also nurses and pharmacists. The error rates remaining high even after the instruction indicates the need for multimodal strategies, including consistent demonstration, teach-back, and

Table 4. Factors Associated with Any Inhaler Technique Error

Factor	DPI OR (95% CI)	p-value	MDI OR (95% CI)	p-value
Age (per year)	1.02 (0.98–1.06)	0.31	1.08 (1.03–1.14)	0.002
Male sex	1.28 (0.55–2.96)	0.57	0.72 (0.30–1.74)	0.47
Education (college+)	0.84 (0.31–2.29)	0.74	1.12 (0.42–2.96)	0.81
Smoking (ever)	1.34 (0.59–3.03)	0.48	1.41 (0.62–3.19)	0.41
Asthma vs COPD	0.90 (0.39–2.04)	0.80	1.25 (0.54–2.88)	0.60
Prior technique training	0.66 (0.26–1.65)	0.37	0.59 (0.24–1.43)	0.24

device reassessment, in addition to instruction.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design limits the ability to assess long-term retention of inhaler technique skills or the sustained impact of education over time. Second, inhaler technique was evaluated in a single-centre tertiary care setting, which may limit the generalizability of the results to other healthcare settings or community-based populations.

Third, inhaler technique assessment was based on direct observation, which may have introduced observer bias despite the use of standardized checklists. Fourth, the post-instruction assessment evaluated only immediate improvement, without follow-up to determine whether the technique improvements were maintained. Additionally, inhaler technique was assessed using demonstration rather than objective measures of lung drug deposition.

Finally, the study did not evaluate the relationship between inhaler technique errors and clinical outcomes such as symptom control, exacerbation frequency, or quality of life. Future multicenter longitudinal studies incorporating clinical outcome measures and repeated educational interventions are warranted to elucidate further the impact of inhaler technique optimization on disease management.

Conclusion

This study demonstrates that inhaler technique errors are highly prevalent among adults with obstructive airway disease who use both dry powder and metered dose inhalers. More than 90% of patients in both groups exhibited at least one technique error before instruction, highlighting a critical gap between inhaler prescription and effective drug delivery. Although structured inhaler technique education resulted in a significant reduction in errors, a substantial proportion of patients continued to demonstrate incorrect technique after instruction, underscoring the need for repeated reinforcement and regular reassessment.

Breathing-related errors were the most common across both inhaler types, while device-specific challenges such as coordination errors were more prominent among MDI users. Increasing age was independently associated with inhaler technique errors in MDI users, suggesting that older patients may require tailored educational strategies or alternative device selection. Overall, these findings emphasize that inhaler technique training should be an integral, ongoing component of routine respiratory care, involving multidisciplinary healthcare providers to optimize clinical outcomes in patients with obstructive airway disease.

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