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Original Research

Pressurized Metered Dose Inhaler (pMDI) versus Dry Powdered Inhaler (DPI) in Asthma: A Comparative Clinical Study

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Abstract: **Background:** Asthma is a chronic inflammatory airway disease for which good drug delivery is critical to optimal control. Pressurized metered-dose inhalers (pMDI) and dry powder inhalers (DPI) are the two preferred inhaler devices for the administration of inhaled corticosteroids and beta-2 agonists, but the relative effectiveness of these devices is controversial. **Objective:** To compare the clinical efficacy of pMDI and DPI in adult asthmatic patients using Asthma Control Test (ACT) and Forced Expiratory Volume in one second (FEV1 (%)) scores as outcome measures. **Methods:** A comparative study was done at the Medicine Outpatient Department, CMH Kharian for three months, from July 2025 to October 2025. One hundred patients with persistent asthma were recruited using non-probability consecutive sampling and assigned into two equal groups of adults. Group A was given Foracort (pMDI) with spacer and Group B was given Combivair Rotacaps (DPI) for four weeks. ACT and FEV1 (%) were measured at baseline, and again after four weeks. Data were analysed by using (SPSS v26) and independent sample t test was used considering p value less than 0.05 as statistically significant. **Results:** Baseline characteristics were comparable between both groups ($p > 0.05$). The DPI group showed a significantly greater mean improvement in ACT (5.29 ± 1.05) compared to the pMDI group (2.91 ± 1.14, $p = 0.001$). Similarly, mean change in FEV_1 was higher in the DPI group (17.92 ± 3.30%) than the pMDI group (14.04 ± 3.15%, $p = 0.001$). **Conclusion:** Both inhaler types improved asthma control and lung function, but DPI demonstrated superior efficacy. DPI may therefore offer a more effective and user-friendly option for outpatient asthma management.

Keywords: Asthma; Metered Dose Inhalers; Dry Powder Inhalers; Adrenal Cortex Hormones; Adrenergic beta-2 Receptor Agonists; Forced Expiratory Volume.

INTRODUCTION

Asthma is a chronic inflammatory disease of the airways with variable respiratory symptoms such as wheezing, shortness of breath, chest tightness and cough, as well as fluctuating expiratory airflow limitation [1]. It forms a significant health issue all over the world, with an estimated 260 million affected worldwide, contributing significantly to morbidity and healthcare burden [2]. In South Asia including Pakistan asthma continues to be under diagnosed and undertreated and it causes preventable complications. Epidemiological studies in Pakistan report adult asthma prevalence to be 4-8% with higher rates reported among the urban population due to the rising air pollution, tobacco exposure, occupational irritants and poor environmental control measures [3, 4].

The cornerstone of asthma management is inhaled pharmacotherapy, specifically inhaled corticosteroids (ICS) for the long-term control of airway inflammation and beta-2 agonists for bronchodilators, both short acting (SABA) and long acting (LABA) for relief of asthma symptoms [1]. These medications are usually delivered by pressurised metered dose inhalers (pMDI), or dry powder inhalers (DPI). pMDI require coordination between actuation and inhalation unlike DPI, which are breath-actuated and require a certain inspiratory flow for optimal drug delivery [5]. Evidence from systematic reviews has suggested that pMDI and DPI, used appropriately, are of similar efficacy in terms of improving lung function, symptom control and exacerbation rates in adults with

asthma [5, 6].

However, device choice, patient preference, inspiratory flow capability, and inhaler technique have notable effects on real-world therapeutic outcomes and thus, comparative assessment of these delivery systems is of clinical significance. In a study, measurements done before therapy and then at the end of pMDI (baseline FEV1 (%); 74.5±11.2, after; 88.5±10.9, change: 14±0.3) and DPI therapy (baseline FEV1 (%); 70.1±24.3, after; 88.2±21.2, change: 18.1±3.1) [7]. In another study, mean ACT scores were significantly better than those after using fixed DPI vs. pMDI (5.8±6.2 vs. 8.5±6.8) [8].
In this study, we will compare the efficacy, in terms of an improvement in FEV1 (%), ACT amongst the two groups of metered dose inhaler and dry powder inhaler as our desirable outcome in a head to head comparison in adult population which will help us in formulation of recommendations for preferred delivery system in asthma control therapy.

METHODS

The research was conducted in the Medicine Outpatient Department of the Combined Military Hospital (CMH) of Kharian for a period of three months, from July 2025 to October 2025 after the approval of the research proposal by the Ethical Review Committee of the hospital. Before taking part, written informed consent was obtained from all subjects. A comparative study methodology was used with a sampling approach of non-probability consecutive sampling. The sample size was calculated using the WHO calculator, yielding a total of 100 patients, with 50 participants in each study group. The calculation was based on a 5% significance level, 80% power of the test, and mean change in FEV_1 values reported as 14±0.3 for the metered dose inhaler (MDI) group and 18.1±3.1 for the dry powder inhaler (DPI) group [7].

Patients of both genders aged between 18 and 70 years who were diagnosed with persistent asthma for at least six months, according to the operational definition, were included in the study. Only those who had not received any prior oral treatment for asthma were eligible for inclusion. Exclusion criteria included pregnancy, lactation, evidence of upper or lower respiratory tract infection as determined by history, clinical examination, or chest X-ray (PA view), acute asthma exacerbation requiring emergency treatment or hospitalization within four weeks prior to the first visit, use of oral corticosteroids within the past four weeks or depot corticosteroids within the previous twelve weeks, and a smoking history exceeding ten pack-years.

After enrollment, patients were consecutively allocated into two equal groups. Group A received Foracort in the form of a pressurized metered dose inhaler (pMDI) at a dosage of 6/400 µg, administered as two actuations twice daily with an ABLE spacer device for a duration of four weeks. Group B received Combivair Rotacaps, a dry powder inhaler (DPI), at a dosage of 400/6 µg using a Revolizer device, also taken twice daily for four weeks. All patients received standardized training on inhaler technique at baseline, including verbal instructions and demonstration of device use. Patients were asked to perform return-demonstration, and incorrect steps were corrected. Inhaler technique was reassessed at follow-up visits to ensure proper usage.

Baseline measures included documentation of patient demographics (age, sex, address, and contact number), measurement of baseline forced expiratory volume in one second (FEV1 (%)) and Asthma Control Test (ACT) scores. Follow-up assessments were performed at the fourth week where FEV1 (%) and ACT were again evaluated using spirometry and the standardised version of ACT questionnaire. The change in the mean of every variable (ACT and FEV1 (%)) was calculated as the difference between the post-treatment and baseline values. The definitions to calculate the changes were as follows: Mean change in ACT=ACT after 4 weeks - ACT at baseline; Mean change in FEV1 (%)=FEV1 (%) after 4 weeks - FEV1 (%) at baseline. Data collection was done using a pre designed proforma by the trainee researcher. All possible sources of bias were minimised through a rigorous following of the inclusion and exclusion criteria.

Baseline instruction was given to all patients on inhaler technique in order to decrease variability concerning the device handling. Yet, other reasons like the experience in inhalers, compliance with the treatment, and personal rates of inspiratory flow have not been directly measured and quantified in the study. A total of 100 patients were enrolled and completed the study. There were no losses to follow-up, and no missing data were observed; therefore, complete case analysis was performed.

Data collection and statistical analysis were performed using version 26.0 of the programme Statistical Package and Data Analysis (SPSS). Quantitative variables, including age, disease duration, ACT, and FEV1 (%) were summarised as means with standard deviations while qualitative variables, including gender and smoking status were summarised as frequencies and percentages. To examine the mean differences of ACT and FEV1 (%) between the two groups, the independent sample t-test was used.

Data were stratified according to age, gender, smoking status and duration of disease to control for possible effect modifiers and independent sample t-tests were performed post-stratification. The effect sizes, as well as 95% confidence intervals (CIs) were

also computed in addition to the p-values to measure the extent and accuracy of differences between the groups. The effect size of continuous variables was estimated using Cohen d. The normality and homogeneity of variance assumptions were tested before administering parametric tests with the help of the Shapiro Wilk test and Levene test, respectively. A p-value of <=0.05 was considered to be statistically significant.

RESULTS

Each group consisted of 50 patients, with almost equal proportions of males and females (52.0% vs. 54.0% males in Group A and B, respectively). Most of the patients were older than 50 years (Group A: 62.0%; Group B: 60.0%), with similar mean age (52.4 +- 16.29 vs. 52.1 +- 17.01 years). Most patients suffered from asthma for more than 10 months, with the mean duration of disease being 13.22 ±3.81 months in Group A and 12.94 ± 3.77 months in Group B (Table-1).

Table-1: Comparison of distribution of different variables between groups

Variables		Groups	
		Group-A (pMDI)	Group-B (DPI)
Gender	Male	26(52.0%)	27(54.0%)
	Female	24(48.0%)	23(46.0%)
Age groups	≤50 years	19(38.0%)	20(40.0%)
	>50 years	31(62.0%)	30(60.0%)
	Mean±S.D	52.4±16.29	52.1±17.01
Duration of disease	≤10 months	15(30.0%)	16(32.0%)
	>10 months	35(70.0%)	34(68.0%)
	Mean±S.D	13.22±3.81	12.94±3.77
Current smoker	Yes	16(32.0%)	17(34.0%)
	No	34(68.0%)	33(66.0%)

Baseline ACT and FEV1 (%) values did not differ between groups ($p > 0.05$), validating that clinical status was similar. After the 4 weeks' treatment period, the two groups both showed a significant improvement, but the mean increase in ACT was greater in the DPI group than in the pMDI group (from 15.16 +- 2.95 to 20.45 +- 3.43 vs 14.16 +- 3.19 to 17.07 +- 3.33, respectively; $p = 0.001$; mean change was 5.29 +- 1.05 vs 2.91. Similarly, the mean FEV1 (%) also showed significant improvement in both groups but the DPI group showed better improvement (mean change 17.92 + 3.30) than the pMDI group (14.04 + 3.15) and was also statistically significant ($p = 0.001$).

The average change in ACT score was much greater in the DPI group than in the pMDI group (mean difference = 2.38, $p = 0.001$), and the effect size (Cohen d = 2.16) was too large. The mean of the difference between the two had a 95 percent confidence interval (CI) of 1.95 to 2.81, which represents a satisfactorily accurate and clinically prominent difference. Likewise, the FEV1 (%) showed a substantially higher improvement in the DPI group than in the pMDI group (mean difference = 3.88, $p = 0.001$), and the effect size (Cohen d = 1.21) was very large. The CI of the 95 percent of the difference between the means was between 2.65 and 5.11, which also indicates the superiority of DPI therapy (Table-2).

Table-2: Comparison of mean ACT and FEV1 (%) at baseline, 4 weeks and mean change between groups

Mean ACT and FEV1 (%)	Groups		p-value
	Group-A (pMDI)	Group-B (DPI)	
Mean ACT at baseline	14.16±3.19	15.16±2.95	0.107
Mean ACT at 4 weeks	17.07±3.33	20.45±3.43	0.001
Mean change in ACT	2.91±1.14	5.29±1.05	0.001
	Mean diff. (2.38), 95% CI (1.95 to 2.81), Cohen's d (2.16)		
Mean FEV1 (%) at baseline	64.28±13.56	65.31±11.69	0.114
Mean FEV1 (%) at 4 weeks	78.22±13.68	86.07±10.91	0.002
Mean change in FEV1 (%)	14.04±3.15	17.92±3.30	0.001
	Mean diff. (3.88), 95% CI (2.65 to 5.11), Cohen's d (1.21)		

Table 3 and Table 4 show the stratified analyses of mean change of ACT and FEV1 (% predicted) between the two treatment groups in terms of gender, age, duration of disease, and smoking status. In all sub-groups, patients receiving dry powder inhalers (DPI) showed significantly higher improvements in both asthma control and pulmonary function than patients receiving pressurised metered dose inhalers (pMDI). The differences were statistically significant ($p = 0.001$) in all categories, so DPI therapy was significantly more effective regardless of patient demographics or clinical characteristics.

Table-3: Stratification of mean change in ACT between groups with respect to different variables

Variables	Group-A (pMDI)	Group-B (DPI)	p-value
Gender			
Male	2.81±1.20	5.19±1.03	<0.0000001
Female	3.01±1.09	5.41±1.09	<0.0000001
Age groups			
≤50 years	2.77±1.02	5.58±1.28	<0.001
>50 years	2.99±1.21	5.10±0.84	<0.001
Duration of disease			
≤10 months	2.83±1.38	5.19±1.08	<0.001
>10 months	2.94±1.04	5.34±1.05	<0.001
Current smoker			
Yes	3.06±1.33	4.81±1.06	<0.001
No	2.84±1.05	5.54±0.97	<0.001

Table-4: Stratification of mean change in FEV1 (%) between groups with respect to different variables

Variables	Group-A (pMDI)	Group-B (DPI)	p-value
Gender			
Male	13.70±3.24	18.13±3.09	<0.001
Female	14.41±3.08	17.69±3.58	0.002
Age groups			
≤50 years	13.41±3.20	17.83±3.22	<0.001
>50 years	14.43±3.11	17.99±3.40	<0.001
Duration of disease			
≤10 months	14.03±4.02	18.35±2.89	<0.002
>10 months	14.05±2.77	17.72±3.50	<0.001
Current smoker			
Yes	13.51±3.22	17.94±3.16	<0.001
No	14.29±3.14	17.92±3.42	<0.001

DISCUSSION

Asthma is a chronic, inflammatory, disease of the airways where airway obstruction is reversible, hyper-responsiveness and variable respiratory symptoms are present (wheezing, cough, and shortness of breath). It has a global impact on more than 300 million people and remains an important cause of morbidity and healthcare burden despite the latest advances in treatment modalities [9, 10]. The cornerstone of asthma management is inhaled corticosteroids (ICS) and beta-2 agonists which alleviate inflammation and assist in improving airway function if delivered effectively to the lower respiratory tract [11, 12].

However, the efficacy of these medications is strongly dependent on the delivery device and inhalation technique by the patient. Pressurized metered-dose inhalers (pMDI) and dry powder inhalers (DPI) are the most popular devices among these, but the comparative effectiveness of the MDI/DPM device in optimal asthma control and improvement in lung functions remains controversial [13, 14].

The purpose of the present study was to compare the clinical effectiveness in achieving good control of asthma in adults treated with inhaled corticosteroids and beta-2 agonists with pMDI and DPI conducted in an outpatient setting. Asthma Control Test (ACT) and forced expiratory volume in one second (FEV1 (%)) were used as the efficacy measures. The results showed significant improvement in both ACT and FEV1 (%) after four weeks of treatment in both groups, but more noticeable improvements were found in DPI users.

In this study, the mean improvement of ACT was 5.29 +/- 1.05 in the DPI group when compared to 2.91 +/- 1.14 in the pMDI group (p = 0.001). Likewise, mean FEV1 (%) increase was 17.92 +- 3.30% in the DPI group and 14.04 +- 3.15% in the pMDI group (p = 0.001). Thus, these findings indicate that DPI were more effective in the improvement of both asthma control and pulmonary function at four weeks. Similar results were found by Lavorini et al. who found improvement in mean FEV1 (%) with DPI (18.1 +- 3.2%) compared with the pMDI (14.0 +- 2.8%) in adult asthmatics [15]. Similarly, Usmani et al. concluded that DPI use resulted in greater improvements in symptom control and lower variability in peak expiratory flow due to improved drug deposition in the peripheral airways [16].

Busby J emphasized that inhaler technique plays a vital role in determining treatment success, reporting that up to 80% of patients make at least one critical

error when using pMDI, whereas the breath-actuated mechanism of DPI reduces this risk substantially [17]. This mechanical advantage could explain the superior efficacy observed in our DPI group. Additionally, Lee Y et al. found that adherence rates were higher among DPI users (mean adherence 84.6 ± 6.8%) compared to pMDI users (79.2 ± 7.3%), which correlated positively with ACT score improvement [18].

In contrast, some studies have reported no significant difference between the two devices when proper inhalation technique and adherence are maintained. Capanoglu et al. found mean FEV_1 improvements of 16.2 ± 3.5% and 15.8 ± 3.2% for DPI and pMDI groups, respectively ($p = 0.64$), suggesting that both devices can be equally effective if patients are well trained [19]. Likewise, Haughney et al. observed similar outcomes in ACT improvement (4.8 ± 1.3 vs. 4.5 ± 1.4, $p = 0.09$) when education on inhaler use was reinforced throughout the study period [20].

These differences indicate that inhaler technique training is a crucial determinant of therapeutic success, potentially influencing inter-study variability. Our study ensured standardized inhaler training before device allocation, which may have minimized technique-related errors and allowed a more accurate comparison of intrinsic device efficiency. The breath-actuated nature of DPI likely enhanced drug delivery by synchronizing inhalation and aerosol generation, thereby minimizing coordination errors common with pMDI. Hassan MI et al. and Laube et al. both reported that DPI deliver a higher fine particle fraction at optimal inspiratory flow rates (≥30 L/min), leading to better peripheral lung deposition and greater clinical response [21, 22].

Smoking status and age are known to influence lung mechanics and inhaler technique. In our study, DPI demonstrated superior outcomes across all stratified variables, including smokers and patients aged >50 years. Melani et al. previously showed that older adults and smokers exhibit significantly higher rates of pMDI handling errors (up to 45%) compared with DPI users (27%), supporting our findings [23]. Furthermore, Salvi et al. emphasized that ease of use and patient preference are major factors enhancing adherence, with DPI rated as more user-friendly and portable than pMDI [24].

Limitations and Future Recommendations

This study was performed at a single tertiary care hospital with relatively small sample size which could restrict its external validity. Follow-up was of four weeks, which is appropriate for the short-term assessment of improvement, but inadequate for the long-term assessment of treatment outcomes such as exacerbation rates and sustained compliance. Additionally, only ACT and FEV1 (%) were selected as outcome measures; biomarkers such as exhaled NO (FeNO) or eosinophil counts which will have been useful for better insight into the anti-inflammatory effect of therapy were not included in the study.

Some of the factors which can be relevant to this inhaler were not measured in this research. These are patient compliance to treatment, previous experience with inhaler devices and personal inspiratory flow rates that are especially vital in maximum DPI performance. These differences and variances in these factors might have had an impact on treatment results and be one of the causes of the differentiation measured between groups. In the future research, objective adherence measures, pre-inhaler usage and inspiratory flow should be included to give a more detailed comparison.

Further studies should be multicenter studies with longer follow-up periods to assess long-term efficacy, adherence rates and exacerbation rates. The addition of objective measures of inflammation and quality-of-life parameters would make the evidence base even more robust. Moreover, studies focused on the comparison of cost-effectiveness and patient-preference could guide the choice of individual therapy in clinical practice.

CONCLUSION

The pressurized metered-dose inhalers (pMDIs) as well as the dry powder inhalers (DPIs) led to positive outcomes in the asthma control and pulmonary functions in four weeks of treatment. Nevertheless, in this study population, DPIs showed a higher improvement in ACT and FEV one scores. Even though these are encouraging results that may indicate an ultimately beneficial effect of DPIs, the findings may be viewed with some skepticism because of the relatively short nature of the study and the single center nature. It is suggested that further large-scale, long-term studies are necessary to validate these findings to come up with conclusive clinical preference.

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