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Original Research Article

Inhaler Technique Errors and Their Association with Asthma Control among Adult Patients: A Cross-Sectional Study

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ABSTRACT

Background: Incorrect inhaler technique can reduce pulmonary drug deposition and contribute to persistent symptoms despite appropriate prescribing. This study assessed the frequency and pattern of inhaler technique errors and examined their association with Asthma Control Test (ACT) scores among adults with asthma.

Methods: In this cross-sectional study, 100 adults using a pressurised metered-dose inhaler (pMDI), dry-powder inhaler (DPI), or pMDI with spacer demonstrated their usual technique. Device-relevant errors were recorded with a predefined checklist. Asthma was classified as controlled (ACT 20-25), partly controlled (ACT 16-19), or uncontrolled (ACT 5-15). Chi-square, Spearman rank correlation, and Mann-Whitney U tests were used as appropriate.

Results: The mean age was 48.06±13.46 years. At least one technique error was observed in 87 patients (87.0%), and the mean error count was 3.10±2.17. Failure to hold the breath after inhalation was the most frequent error (n=79). Mean ACT score was 18.19±4.97; 44 patients had controlled asthma, 20 partly controlled asthma, and 36 uncontrolled asthma. Error count had a strong inverse correlation with ACT score (rho=-0.991, $p<0.001$). Asthma-control distribution differed significantly across error categories (chi-square=119.00, $p<0.001$). Patients with prior inhaler education had fewer errors and higher ACT scores than those without prior education (both $p<0.001$).

Conclusion: Inhaler technique errors were frequent and closely associated with poorer ACT-based asthma control. Direct observation, correction of device-specific errors, and repeated teach-back education should form part of every asthma review.

Keywords: Asthma, Inhaler Technique, Asthma Control Test, Patient Education, pMDI, Dry-Powder Inhaler.

INTRODUCTION

Inhaled therapy remains fundamental to asthma management because it delivers medication directly to the airways while limiting systemic exposure. The clinical benefit, however, depends on whether the patient can complete the sequence required by the selected device. Current asthma guidance therefore places inhaler-technique assessment alongside adherence review before treatment is intensified.[1]

Asthma control is influenced by airway inflammation, environmental exposure, treatment intensity, adherence, comorbidity, and the quality of inhaled drug delivery. The Asthma Control Test (ACT) offers a brief, patient-reported measure suitable for routine practice and has demonstrated acceptable reliability, validity, and responsiveness.[2,3] A low score may nevertheless be interpreted as treatment failure when the immediate problem is a correctable handling error. Incorrect inhaler use remains common across device

types. A systematic review covering four decades identified recurrent problems with actuation-inhalation coordination, inspiratory manoeuvre, exhalation before inhalation, and post-inhalation breath-holding.[4] Large real-world studies have further shown that selected critical errors are associated with uncontrolled asthma, exacerbations, healthcare use, and reduced therapeutic benefit.[5-8]

The problem is especially relevant in Indian outpatient practice, where patients may use multiple device formats, receive instruction of uneven quality, or continue a technique learned several years earlier without reassessment. Indian studies have documented frequent errors among patients using inhaled treatment and have also identified deficiencies in the technique of healthcare personnel expected to provide instruction.[9-11] The present study therefore evaluated the prevalence and pattern of inhaler technique errors among adult patients with asthma and examined their association with ACT-based asthma control. The relationships of prior inhaler education and age with error burden were also assessed.

MATERIALS AND METHODS

Study Design and Setting

A cross-sectional observational study was conducted in the Department of Respiratory Medicine, in a Tertiary care South Indian teaching hospital for a period of 6 months. The study included 100 adult patients receiving inhaled therapy for asthma.

Study Variables and Inhaler Assessment

Age, gender, educational level, occupation, smoking status, inhaler type, and previous formal inhaler education were recorded. Inhaler devices were categorised as pressurised metered-dose inhaler (pMDI), dry-powder inhaler (DPI), or pMDI used with a spacer.

Each participant was asked to demonstrate the usual method of using the prescribed inhaler. Technique was evaluated using a predefined checklist containing device-relevant steps. The recorded errors were failure to shake a pMDI before use, failure to exhale fully before inhalation, poor coordination between actuation and inhalation, inadequate inspiratory flow with a DPI, failure to hold the breath for 5-10 seconds after inhalation, repeated actuation without re-shaking, failure to rinse the mouth after inhaled corticosteroid use, failure to remove the cap or inverted device use, omission or incorrect assembly of a spacer, and failure to breathe out gently after inhalation.

Assessment of Asthma Control

Asthma control was assessed using the ACT, which yields a score from 5 to 25. Scores of 20-25 were classified as controlled asthma, 16-19 as partly controlled asthma, and 5-15 as uncontrolled asthma.

Statistical Analysis

Continuous variables were summarised using mean±standard deviation or median with interquartile range, according to their distribution. Categorical variables were expressed as frequency and percentage. Error burden was grouped as 0-2, 3-5, and 6-7 errors. The chi-square test assessed associations between categorical variables. Spearman rank correlation evaluated the relationships of error count with ACT score and age. ACT scores and error counts were compared according to prior inhaler education using the Mann-Whitney U test. A two-sided p-value <0.05 was considered statistically significant.

Ethical Considerations

The study was conducted after approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants, and confidentiality was maintained.

RESULTS

The study included 100 adults aged 25-73 years, with a mean age of 48.06±13.46 years. Men constituted 53% of the cohort. Secondary education was the most frequent educational category (40%), and 49% were employed. Fifty-six participants had never smoked. A pMDI was used by 59 patients, a DPI by 21, and a pMDI with spacer by 20. Previous formal inhaler education was reported by 45 patients (Table 1).

Characteristic	Value
Age, years	48.06±13.46 (25-73)
Gender	Male: 53 (53.0%); Female: 47 (47.0%)
Education	Primary: 29 (29.0%); Secondary: 40 (40.0%); Graduate: 31 (31.0%)

Occupation	Employed: 49 (49.0%); Homemaker: 22 (22.0%); Retired: 28 (28.0%); Unemployed: 1 (1.0%)
Smoking status	Never: 56 (56.0%); Former: 26 (26.0%); Current: 18 (18.0%)
Inhaler type	pMDI: 59 (59.0%); DPI: 21 (21.0%); pMDI with spacer: 20 (20.0%)
Prior formal inhaler education	Yes: 45 (45.0%); No: 55 (55.0%)

Table 1. Baseline Characteristics of the Study Participants (n=100)

Values are n (%) unless otherwise specified. pMDI: pressurised metered-dose inhaler; DPI: dry-powder inhaler

At least one inhaler technique error was recorded in 87 participants (87.0%), while 13 demonstrated no recorded error. The mean number of errors was 3.10±2.17, with a range of 0-7. Failure to hold the breath after inhalation was the most frequent error (n=79). Failure to shake the pMDI and poor actuation-inhalation coordination were each recorded in 45 participants, while failure to rinse the mouth after inhaled corticosteroid use occurred in 40 (Table 2 and Figure 2).

Code	Technique error	n
E1	Failure to shake the pMDI before use	45
E2	Failure to exhale fully before inhalation	34
E3	Poor coordination between actuation and inhalation	45
E4	Inadequate inspiratory flow with a DPI	17
E5	Failure to hold the breath after inhalation	79
E6	Repeated actuation without re-shaking the pMDI	30
E7	Failure to rinse the mouth after inhaled corticosteroid use	40
E8	Cap not removed or inhaler used in an inverted position	0
E9	Spacer omitted or assembled incorrectly	14
E10	Failure to breathe out gently after inhalation	6

Table 2. Frequency of Recorded Inhaler Technique Errors

Errors were not mutually exclusive. Device-specific steps were assessed only where applicable

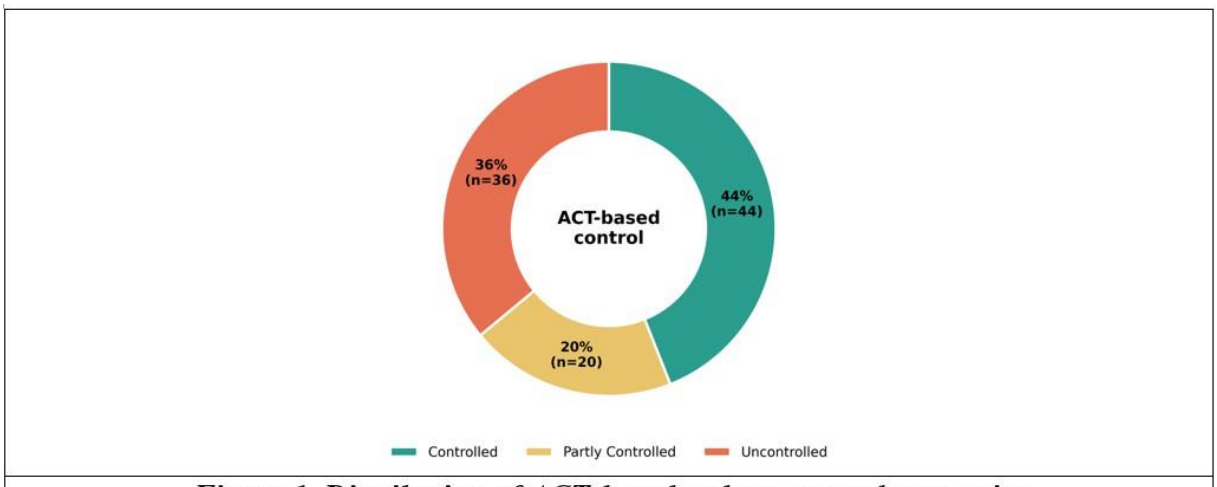

Figure 1. Distribution of ACT-based asthma-control categories

Segment labels show percentage and patient count

The mean ACT score was 18.19±4.97 (range 10-25). Forty-four patients had controlled asthma, 20 had partly controlled asthma, and 36 had uncontrolled asthma (Figure 1). Control status differed substantially across error-burden categories. Among patients with 0-2 errors, 44 of 45 (97.8%) had controlled asthma and one had partly controlled asthma. In the 3-5 error category, 19 of 38 (50.0%) had partly controlled asthma and 19 (50.0%) had uncontrolled asthma. All 17 patients with 6-7 errors had uncontrolled asthma. The association was statistically significant (chi-square=119.00, df=4, $p<0.001$) (Table 3 and Figure 3).

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Error category	Controlled	Partly controlled	Uncontrolled	Total
0-2 errors	44 (97.8%)	1 (2.2%)	0 (0.0%)	45
3-5 errors	0 (0.0%)	19 (50.0%)	19 (50.0%)	38
6-7 errors	0 (0.0%)	0 (0.0%)	17 (100.0%)	17

Table 3. Association between Inhaler-Error Burden and Asthma Control

Row percentages are shown. Chi-square=119.00; df=4; p<0.001

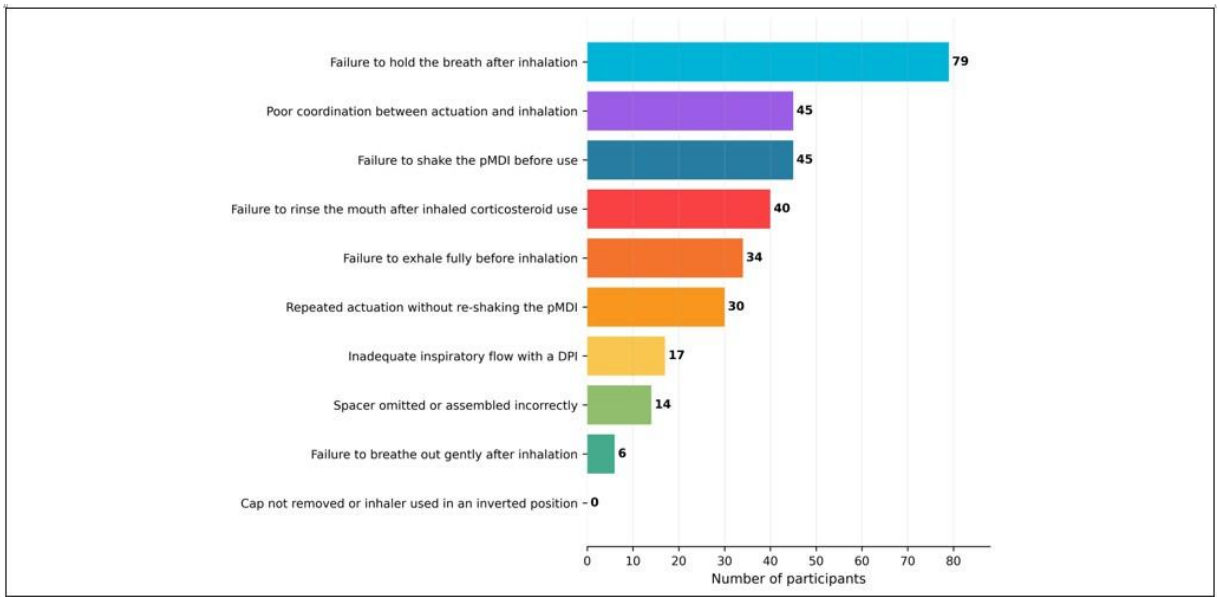

Figure 2. Frequency of specific inhaler technique errors

Bars represent patient counts; individual patients could have more than one error

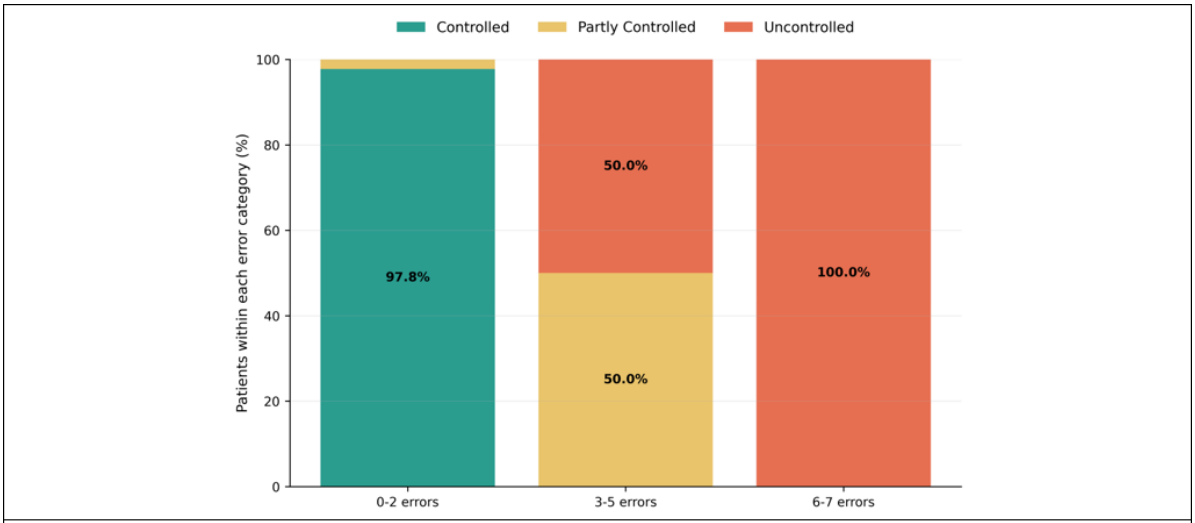

Figure 3. Asthma-control distribution across inhaler-error categories

Each column represents all patients within the corresponding error category

Error count showed a strong inverse correlation with ACT score (rho=-0.991, p<0.001). Age had a moderate positive correlation with error count (rho=0.550, p<0.001). Patients who had received prior inhaler education had a median of 1 error (IQR 0-2), compared with 5 errors (IQR 4-6) among those without prior education (U=0.0, p<0.001). Their median ACT scores were 23 (IQR 22-25) and 14 (IQR 12-16), respectively (U=2474.5, p<0.001). Asthma-control distribution was also associated with prior education (chi-square=96.16, df=2, p<0.001) (Table 4 and Figure 4).

Association	Statistical test	Statistic	p-value
Inhaler-error count vs ACT score	Spearman correlation	rho=-0.991	<0.001
Age vs inhaler-error count	Spearman correlation	rho=0.550	<0.001
Prior education: error count	Mann-Whitney U	U=0.0	<0.001
Prior education: ACT score	Mann-Whitney U	U=2474.5	<0.001
Prior education vs asthma-control category	Chi-square	chi-square=96.16	<0.001

Table 4. Key Statistical Associations Involving Inhaler Technique and Asthma Control

All tests were two-sided

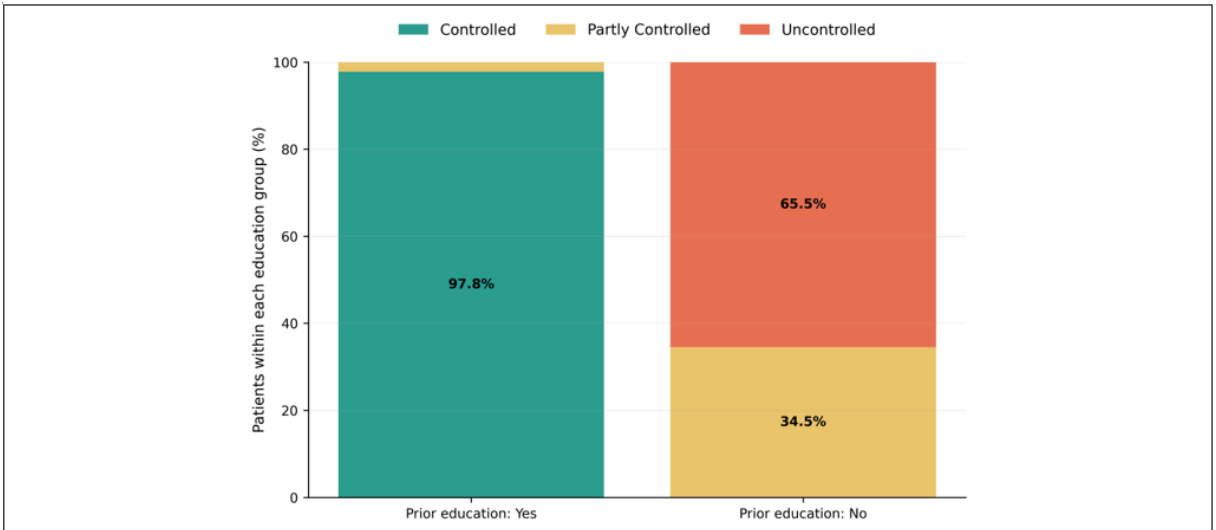

Figure 4. Asthma-control distribution according to prior inhaler education

Each column represents all patients within the corresponding education group

DISCUSSION

This cross-sectional study identified a high burden of inhaler technique errors among adults receiving inhaled treatment for asthma. Eighty-seven percent committed at least one error during observed use. More importantly, the number of errors was closely aligned with ACT-based symptom control: ACT scores declined as error burden increased, and every participant in the highest error category had uncontrolled asthma. The design cannot establish causality, but the clinical direction is plausible because inhaled therapy can achieve its intended effect only when the device is prepared and operated correctly.

The prevalence observed here is comparable with the high error rates reported in Indian respiratory practice. Arora et al. found at least one handling error in 82.3% of patients with asthma or chronic obstructive pulmonary disease, with the greatest error burden among metered-dose inhaler users.[9] Padmanabhan et al. reported a lower, though still substantial, prevalence of incorrect technique in a larger Indian cohort.[11] Variation between studies is expected because device mix, number of assessed steps, definition of a critical error, previous training, and observer method are not uniform.

Failure to hold the breath after inhalation was the most frequent error in the present cohort. The broader inhaler literature similarly identifies omission of post-inhalation breath-holding as a recurrent problem across pMDIs and DPIs.[4] The high frequency of pMDI preparation and coordination errors also deserves attention. A pMDI requires synchronisation between actuation and a slow, deep inhalation, a sequence that many patients find difficult to reproduce. In the CRITIKAL study, selected device-specific errors were associated with uncontrolled asthma and exacerbation risk rather than representing harmless procedural variation.[5]

The strong inverse relationship between error count and ACT score is consistent with earlier real-world observations. Melani et al. linked inhaler mishandling with poorer disease control and greater healthcare use.[6] Al-Jahdali et al. reported that improper technique was associated with uncontrolled asthma and more frequent emergency-department attendance.[7] Levy et al. also found that inability to use a pMDI correctly correlated with poor asthma control in routine practice.[8]

Together, these findings support checking technique before interpreting persistent symptoms as pharmacological failure or escalating therapy.

Prior education was associated with fewer errors and better ACT scores. Training should therefore be viewed as part of treatment delivery, not an optional addition. Still, instruction cannot be treated as a one-time intervention. Rootmensen et al. found that previous instruction increased the likelihood of correct inhaler use, whereas device complexity and the use of multiple inhaler types could undermine performance.[12] Indian evidence has also shown that patients may receive incomplete demonstrations and that healthcare personnel themselves may not consistently perform every required step.[10] The practical response is brief, repetitive, and demonstration based. Patients should be asked to use their own device while the clinician observes. Errors can then be corrected through demonstration followed by teach-back. Systematic reviews have associated critical inhaler errors with worse health outcomes, although intervention studies vary in design and effect size.[13,14] A focused ten-minute educational session has nevertheless been shown to improve inhaler knowledge, technique, and ACT-defined control over follow-up.[15] In busy Indian outpatient departments, even a two- or three-minute device-specific teach-back process may be more useful than verbal reassurance or an English-language leaflet alone.

Age was moderately associated with greater error burden. Older adults may encounter reduced dexterity, visual limitation, lower inspiratory capacity, or difficulty retaining a multi-step sequence. This does not argue against inhaled treatment. It supports individualised device selection, spacer use where appropriate, regimen simplification, caregiver involvement, and repeated reassessment in the patient's preferred language.

Several limitations should be considered. The cross-sectional design prevents causal inference, and asthma control may also be influenced by adherence, disease severity, environmental exposure, comorbidities, and treatment intensity. The study was conducted in a single departmental setting with a modest sample, which limits generalisability. Technique was observed at one encounter and could have been influenced by the Hawthorne effect. All recorded errors were counted equally even though individual steps may have different effects on lung deposition. Medication adherence, spirometry, exacerbation history, and treatment step were not available for multivariable adjustment. Finally, the near-complete separation of ACT-based control across error and education categories produced very strong statistical associations; these estimates require confirmation in an independent cohort using prespecified critical-error definitions.

CONCLUSION

Inhaler technique errors were common among adults with asthma and were strongly associated with lower ACT scores and poorer asthma-control categories. Omission of post-inhalation breath-holding, pMDI preparation errors, and actuation-inhalation discoordination were prominent. Previous formal education was associated with fewer errors and better control. Direct observation, teach-back correction, and periodic reassessment of device technique should be incorporated into routine asthma care before treatment is intensified.

Author Contribution

Dr. Nisha Bopaiah K. (First Author) contributed to the conceptualization of the study, investigation, case management, supervision, and critical review and editing of the manuscript.

Dr. Harshith K. H. (Second Author) conducted the literature review and prepared the original draft of the manuscript.

Dr. Madhu Sudhan Y. (Third Author) contributed to project administration and critically reviewed and edited the manuscript.

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Nil.

Conflict of Interest

None declared.

REFERENCES

1. Global Initiative for Asthma. Global strategy for asthma management and prevention [Internet]. Fontana (WI): Global Initiative for Asthma 2026 [cited 2026 Jul 28]. Available from: https://ginasthma.org/2026-gina-strategy-report/
2. Nathan RA, Sorkness CA, Kosinski M, et al. Development of the Asthma Control Test: a survey for assessing asthma

control. J Allergy Clin Immunol 2004;113(1):59-65.

3. Schatz M, Sorkness CA, Li JT, et al. Asthma Control Test: reliability, validity, and responsiveness in patients not previously followed by asthma specialists. J Allergy Clin Immunol 2006;117(3):549-56.
4. Sanchis J, Gich I, Pedersen S, et al. Systematic review of errors in inhaler use: has patient technique improved over time? Chest 2016;150(2):394-406.
5. Price DB, Román-Rodríguez M, McQueen RB, et al. Inhaler errors in the CRITIKAL study: type, frequency, and association with asthma outcomes. J Allergy Clin Immunol Pract 2017;5(4):1071-1081.e9.
6. Melani AS, Bonavia M, Cilenti V, et al. Inhaler mishandling remains common in real life and is associated with reduced disease control. Respir Med 2011;105(6):930-938.
7. Al-Jahdali H, Ahmed A, Al-Harbi A, et al. Improper inhaler technique is associated with poor asthma control and frequent emergency department visits. Allergy Asthma Clin Immunol 2013;9(1):8.
8. Levy ML, Hardwell A, McKnight E, et al. Asthma patients' inability to use a pressurised metered-dose inhaler correctly correlates with poor asthma control as defined by the Global Initiative for Asthma strategy: a retrospective analysis. Prim Care Respir J 2013;22(4):406-11.
9. Arora P, Kumar L, Vohra V, et al. Evaluating the technique of using inhalation device in COPD and bronchial asthma patients. Respir Med 2014;108(7):992-8.
10. Mullerpattan JB, Udwadia ZZ, Kathar SS, et al. Who will teach the teachers: an analysis of the inhaler technique of Indian patients and health care providers in a tertiary health care centre. Lung India 2016;33(5):493-5.
11. Padmanabhan M, Tamilarasu K, Rajaram M, et al. Inadequate inhaler technique, an everlasting problem, is associated with poor disease control: a cross-sectional study. Adv Respir Med 2019;87(4):217-25.
12. Rootmensen GN, van Keimpema ARJ, Jansen HM, et al. Predictors of incorrect inhalation technique in patients with asthma or COPD: a study using a validated videotaped scoring method. J Aerosol Med Pulm Drug Deliv 2010;23(5):323-8.
13. Kocks JWH, Chrystyn H, van der Palen J, et al. Systematic review of association between critical errors in inhalation and health outcomes in asthma and COPD. NPJ Prim Care Respir Med 2018;28(1):43.
14. Normansell R, Kew KM, Mathioudakis AG. Interventions to improve inhaler technique for people with asthma. Cochrane Database Syst Rev 2017;3(3):CD012286.
15. Schuermans D, Hanon S, Wauters I, Verbanck S, Vandevoorde J, Vanderhelst E. Impact of a single 10 min education session on asthma control as measured by ACT. Respir Med 2018;143:14-7.