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ORIGINAL RESEARCH

Evaluating the Role of Incentive Spirometry in Asthma Management: A Prospective Controlled Study on Spirometry and Asthma Control Test Improvements

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Purpose: Asthma is a chronic lung disease characterized by variable airway obstruction. Despite advancements in pharmacological treatments, interest in non-pharmacological approaches is growing, particularly for variable airway diseases like asthma. Incentive spirometry (IS) is non-pharmacological, inexpensive, safe, and accessible. This study aimed to evaluate the effects of IS on spirometry and asthma control test (ACT) parameters in asthma patients.

Patients and Methods: This was a prospective, controlled, single-center study evaluating the effects of incentive spirometry in stable asthma. A total of 153 patients were included in the study. After applying the exclusion criteria (n=28) and withdrawal criteria (n=45), 80 patients completed the study. All patients who attended IS breathing exercises received training from the relevant physician. Patients who practiced the exercises daily for at least 6 weeks were included in the study.

Results: Of the 80 patients, 57 (71.25%) were female, with a mean age of 54.4 ± 15.8 years. The IS group (n=41) significantly improved FEF 25–75 values and ACT scores. FEF 25–75 increased by 225.3 ± 66.41 mL (10.34 ± 3.07%, p=0.02), and ACT scores improved by 2.1 ± 0.4 points ($p \leq 0.001$). The control group showed no spirometry changes but had a significant ACT score increase of 4.17 ± 0.7 points ($p < 0.001$).

Conclusion: IS improved $FEF_{25–75}$ values and ACT scores, suggesting benefits for small airway function and asthma control. ACT improvements in both groups may be linked to better education and adherence.

Keywords: asthma, breathing exercises, incentive spirometry, asthma control test, spirometry

Introduction

Asthma is a variable and heterogeneous condition that is increasingly conceptualized as a clinical phenotype arising from multiple underlying endotypes, rather than being defined solely by chronic airway inflammation.[1–3] It is characterized by respiratory symptoms such as shortness of breath, wheezing, chest tightness, and coughing.[4] In this framework, airway inflammation is regarded as a common downstream mechanism shared by different endotypes rather than the primary cause of asthma. Hypersensitivity represents the most prevalent endotype and may occur through both IgE-mediated and non-IgE-mediated pathways, while other endotypes, including infectious, nutritional, and pharmacological factors, may also contribute to the development of asthma phenotypes.[5–7] Globally, asthma affects approximately four hundred million individuals and has a prevalence rate of 5–7% in Türkiye.[8] This is a highly prevalent chronic disease that can lead to both mortality and morbidity. As a result, research focusing on its management holds significant clinical importance.[9] The primary goal of asthma maintenance therapy is to reduce or completely prevent exacerbations and to avoid permanent airway obstruction. Inhaled corticosteroids and bronchodilators form the cornerstone of pharmacological treatment. However, pharmacological treatment alone is insufficient. A comprehensive approach that involves reassessing the patient's condition at each visit and adopting

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a biopsychosocial perspective is essential for controlling chronic diseases like asthma. In this regard, non-pharmacological treatment methods are also recommended.[10]

Non-pharmacological therapies include environmental modifications, lifestyle and dietary changes, physical activity, and pulmonary rehabilitation. From a lifestyle and dietary perspective, it is crucial to avoid a sedentary lifestyle, lose weight if obese, and adopt a balanced diet rich in fiber and vitamin E from vegetables. Increasing physical activity and engaging in pulmonary rehabilitation have also been shown to improve the quality of life for asthma patients.[11]

Pulmonary rehabilitation has been shown to reduce areas of hyperinflation, improve the use of the diaphragm and respiratory muscles, decrease respiratory rate, and prolong expiration time.[12] These effects collectively enhance asthma control and improve patients' quality of life. In addition to structured pulmonary rehabilitation programs conducted in hospitals or by healthcare professionals, there are also methods that patients can easily practice at home with similar mechanisms of action.[12]

The incentive spirometry (IS) device, which can be used at home, has positive effects such as opening atelectasis in the airways, prolonging expiration time, reducing areas of hyperinflation, and strengthening respiratory muscles. IS has long been used to reduce postoperative pulmonary complications and in patients with hypercapnic COPD.[13] However, the regular use of IS in patients diagnosed with asthma has yet to be standardized in chronic practice.

In our study, we aimed to evaluate the potential positive effects of IS on spirometry and asthma control test (ACT) parameters in asthma patients who were not experiencing an exacerbation. To date, no prospective controlled studies have specifically evaluated the effects of incentive spirometry on spirometry parameters and ACT scores in patients with stable asthma.

Materials and Methods

Our study was a single-center, prospective, and controlled study. All patient data were anonymized, and patients' names and national identification numbers were redacted during data collection. An informed consent form was provided to all patients prior to participation. This study was conducted at Giresun Dr. Ali Menekşe State Hospital, where the authors were employed during the period of patient recruitment. As this institution did not have an independent ethics committee at that time, ethical approval was obtained from the Giresun Training and Research Hospital Ethics Committee (Approval No: KAEK-222-25/12/2023-1). The study was conducted in full accordance with the principles outlined in the Declaration of Helsinki and its subsequent amendments.

A total of 153 patients were included in the study. After applying the exclusion criteria (n=28) and withdrawal criteria (n=45), 80 patients completed the study. All patients who were to perform incentive spirometry exercises received breathing exercise training from the relevant physician. Patients who practiced the exercises daily for at least 6 weeks were included in the study. Patients diagnosed with asthma and presenting to the pulmonary diseases outpatient clinic who were not in an exacerbation period were divided into incentive spirometry (IS) and control groups. Patients included in the study had no increase in symptoms within the past 15 days, no findings of airway obstruction upon physical examination, and no need for systemic steroids or antibiotics, indicating that they were not in an exacerbation period.

Patients

Patients aged 18–75 years admitted to the pulmonary diseases outpatient clinic of a secondary care hospital, diagnosed with asthma previously treated in steps 3 and 4 according to the Global Initiative for Asthma (GINA) document, capable of performing spirometry (PFT), and not in a state of asthma exacerbation were included in the study. Asthma diagnosis was based on the criteria outlined in the GINA document. Patients with cardinal asthma symptoms, including wheezing, shortness of breath, chest tightness, and persistent cough, were included if they showed variable airway obstruction via SFT or peak expiratory flow (PEF) measurements. Other diseases were excluded clinically and radiologically.

A reversibility test was performed to demonstrate variable airway obstruction in PFT. An increase in forced expiratory volume in one second (FEV_1) of more than 12% or 200 mL was considered a positive reversibility test. For PEF, a daily diurnal variation exceeding 10% was accepted as variable airway obstruction.[4]

Patients experiencing asthma exacerbation were excluded from the study. The definition of asthma exacerbation was based on the GINA document, which describes it as worsening asthma symptoms over an acute or subacute period that

does not resolve with routine treatment. To avoid affecting spirometry parameters, patients who had received systemic steroids or antibiotics for asthma exacerbation within the past 14 days were excluded from the study.[4]

Patients were not randomized; instead, they were assigned sequentially, one by one, to the intervention or control groups in the order of enrollment.

Adherence to incentive spirometry was assessed through regular telephone reminders, verbal confirmation during outpatient clinic visits, and the use of written adherence logs completed by the patients.

Patients with comorbid restrictive disorders, known central nervous system tumors or previous cerebrovascular diseases, uncontrolled hypertension, known chest deformities, a history of thoracic surgery within the past year, known lung malignancies, pregnancy, or contraindications to spirometry were excluded from the study.

Procedures

Spirometry

All patients underwent spirometry using the same device (Cosmed Pony FX), performed by the same technician, for diagnostic confirmation and follow-up purposes. The SFT technician was an experienced professional who had worked at the same hospital for a long time. Spirometry was conducted according to the guidelines of the European Respiratory Society (ERS) and the American Thoracic Society (ATS).[14]

Intensive Spirometer

Our study examines the use of the ODTA incentive spirometer, a respiratory exercise device that is affordable, easy to obtain, and manufactured in Turkey. Patients using incentive spirometry were required to use the device at least three times a day, with 10 repetitions per session, and to have used the device regularly for a minimum of 45 days. Patients meeting these criteria were included in the study.

Asthma Control Test

The Asthma Control Test (ACT) was developed by a team of researchers led by Dr. Robert Nathan.[15] It serves as a concise, patient-administered tool designed to evaluate asthma control. The ACT comprises five questions that address the frequency of shortness of breath, nighttime awakenings, the use of rescue medications, the impact of asthma on daily functioning, and the patient's overall perception of asthma control. Each question is scored on a scale from 1 to 5, with a total score ranging from 5 to 25; higher scores indicate better asthma control.[16] Clinically, the ACT is significant because it enables healthcare providers to identify patients with uncontrolled asthma, monitor treatment progress, and make informed decisions regarding therapy adjustments.[17] The validated Turkish version of the ACT was used.[18]

The demographic and clinical data of the patients were recorded. In addition, spirometry parameters - including Forced Vital Capacity (FVC), FEV_1, FEV_1/FVC ratio, Peak Expiratory Flow (PEF), Forced Expiratory Flow at 25–75% ($FEF_{25–75}$) - and Asthma Control Test (ACT) scores were documented.

These variables were recorded during the initial visit, and informed consent and contact information for the incentive spirometer intervention were obtained. Patients who agreed to participate in the study were provided with an incentive spirometer during the first visit, and its use was explained in detail. Forty-five days were selected for follow-up, as adherence to asthma treatment and its effects are typically evaluated over a 4–6-week period. After 45 days, patients were invited for a follow-up visit, during which the same variables recorded during the first visit were documented again.[9] No changes were made to the patient's treatment regimens, and no medications, such as intravenous corticosteroids, which could rapidly alter spirometry results, were administered.

Statistical Analysis

The variables related to the patients were entered into the SPSS software (IBM, Seattle, version 28.0) for statistical analysis. The Shapiro–Wilk and Kolmogorov–Smirnov tests were applied to assess the normality of data distribution. Mean and standard deviation values were calculated for data following a normal distribution, whereas median and interquartile ranges (25th-75th percentiles) were used for non-normally distributed data.

Demographic and clinical parameters and ACT and spirometry parameters recorded during the first and final visits were compared between the control and treatment groups. Categorical variables were analyzed using the Chi-square test. For continuous variables, the independent *t*-test was used for normally distributed data, and the Mann–Whitney *U*-test was applied for non-normally distributed data.

Additionally, spirometry and ACT parameter changes after treatment were analyzed using paired t-tests within the same patient group. A p-value of less than 0.05 was considered statistically significant.

Results

Eighty patients included in the study were divided into two groups using simple randomization. The IS group comprised 41 patients, while the control group included 39. The patient selection diagram is shown in Figure 1. The mean age of all patients was 54.5 ± 15.5 years, and 71.3% were female. Among the patients, 31.3% had a smoking history, with 18.8% being current smokers and 12.5% being former smokers. The mean FEV_1 value was 2210.1 ± 758.6 mL, and the mean FVC value was 2792.0 ± 908.9 mL. The mean ACT score was determined to be 16.8 ± 3.7.

The control and IS groups were compared in terms of demographic variables, spirometry, and ACT parameters. The mean age was 51.2 ± 16.9 in the control group and 57.6 ± 13.6 in the IS group (p=0.64). The proportion of female patients was similar between the control and IS groups (61.5% and 80.5%, respectively, p=0.08). Smoking history and mean package years were also comparable between the two groups.

In the control group, the baseline mean FEV_1 was 2503.1 ± 762.3 mL (85.1 ± 18.0%), whereas in the IS group, the baseline mean FEV_1 was 1931.5 ± 649.1 mL (73.8 ± 17.6%). In mL and percentage units, FEV_1 values were significantly lower in the IS group. Baseline FVC (mL) values were similar between the groups, but FVC (%) was significantly lower in the IS group (75.3 ± 14.1 vs 85.8 ± 16.8, p=0.003). Baseline $FEF_{25–75}$ was 1899.3 ± 1018.7 mL in the IS group and

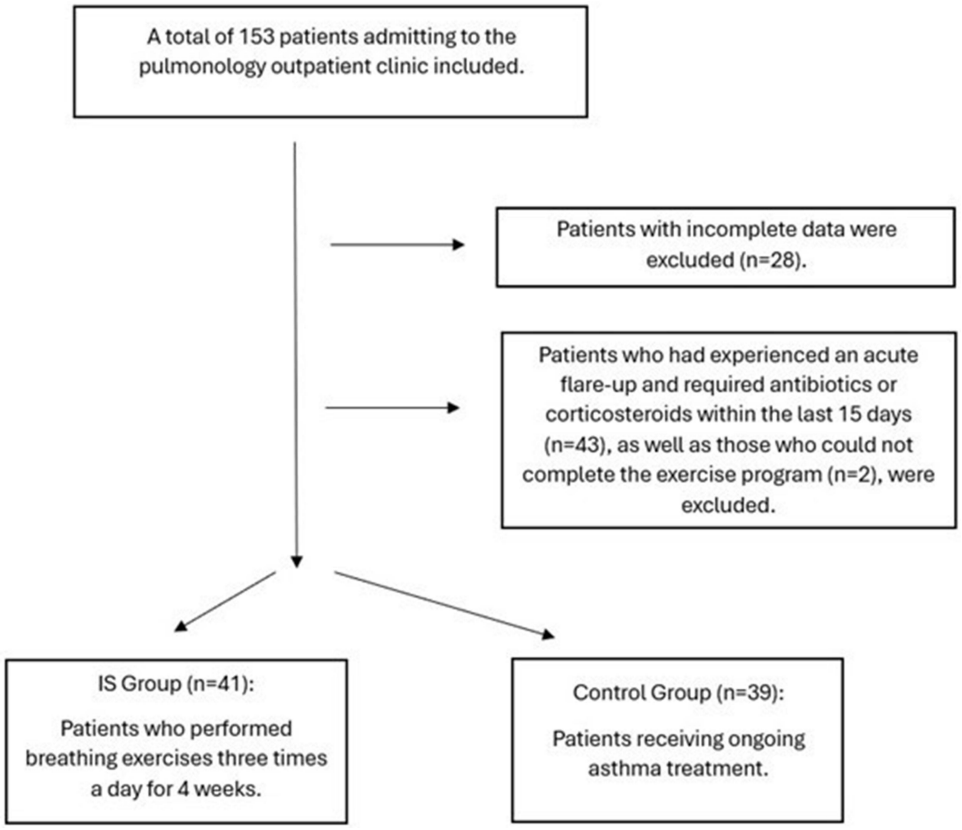

Figure 1 Patient Selection.

2480.8 ± 1160.9 mL in the control group (p=0.021). However, no significant difference was observed in the $FEF_{25–75}$ percentage values between the groups.

When the final spirometry parameters were examined, the IS group's FEV_1 (mL) and $FEF_{25–75}$ (mL) values were found to be significantly lower than those of the control group (Table 1).

When examining the ACT results, we found that the median baseline ACT score in the IS group was 16 (14–18), whereas in the control group, it was 18 (14–22) (p=0.09). The final ACT results were also similar between the two groups. (IS: 18 (16–22), control: 21 (18–23), p=0.61) (Table 1).

We compared the differences between the two groups in baseline spirometry and ACT values. The FEV_1 difference in mL was 12.9 ± 256.9 in the control group and 53.9 ± 178.1 in the IS group, significantly favoring the IS group (p=0.048). No significant differences were found for other spirometry parameters. For ACT, the change was 4.2 ± 4.5 in the control group and 2.1 ± 2.6 in the IS group (p=0.001) (Table 2).

When analyzing the change within the IS group using paired t-tests, no significant differences were found between baseline and final measurements for FEV_1 and FVC. However, significant differences were observed for $FEF_{25–75}$ in both mL and (%) units. A statistically significant difference was also found in ACT scores between baseline and final measurements within the IS group (Table 3).

Table 1 Demographic Data and PFTs of the Patients

Variables	Control Group (n=39)	IS Group (n=41)	p-value
Female (n, %)	24 (61.5)	33 (80.5)	0.08
Age (years)*	51.2±16.9	57.6±13.6	0.64
Non-smoker (n, %)	24 (61.5)	31 (75.6)	0.39
Former smoker (n, %)	9 (23.1)	6 (14.6)	
Current smoker (n, %)	6 (15.4)	4 (9.8)	
Pack-years*	25.4±9.1	19.2±7.6	0.79
FEV1 (mL) baseline*	2503.1±762.3	1931.5±649.1	**<0.001**
FEV1 (%) baseline*	85.1±18.0	73.8±17.6	**0.005**
FVC (mL) baseline**	2460 (2000–3480)	2700 (2205–3295)	0.71
FVC (%) baseline*	85.8±16.8	75.3±14.1	**0.003**
$FEF_{25–75}$ (mL) baseline*	2480.8±1160.9	1899.3±1018.7	**0.021**
$FEF_{25–75}$ (%) baseline*	72.4±35.9	87.4±37.3	0.53
ACT baseline**	18 (14–22)	16 (14–18)	0.09
FEV1 (mL) final*	2445.9±818.4	2051.9±689.3	**0.023**
FEV1 (%) final*	81.7±18.3	78.6±19.2	0.45
FVC (mL) final**	2650 (2010–3200)	2710 (2190–3300)	0.6
FVC (%) final*	80.4±14.4	78.0±14.8	0.48
$FEF_{25–75}$ (mL) final*	2613.3±1285.4	2079.8±1079.7	**0.05**
$FEF_{25–75}$ (%) final*	91.6±45.4	82.9±36.1	0.35
ACT final**	21 (18–23)	18 (16–22)	0.61

Notes: (*) mean±standard deviation (**) median IQR (25–75). Values shown in bold indicate statistically significant differences.

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Table 2 Differentiations Between Pre and Post-Values of Spirometry and ACT Changes Between the Control and IS Groups

Variables	Control Group (n=39)	IS Group (n=41)	p-value
FEV1 (mL)*	12.9±256.9	53.9±178.1	**0.048**
FEV1 (%)*	−1.0±14.6	0.5±122	0.81
FVC (mL)*	−40.8±440.3	−2.9±2831	0.64
FVC (%)*	−0.4±13.6	−1.9±8.6	0.55
$FEF_{25–75}$ (mL)*	84.8±662.4	225.3±452.2	0.26
$FEF_{25–75}$ (%)*	37±20.9	10.3±197	0.15
ACT *	4.2±4.5	2.1±2.6	**0.001**

Notes: (*) mean±standard deviation. Values shown in bold indicate statistically significant differences.

Table 3 Comparison of Baseline and Final Mean Values within the IS Group

Variables	IS Group (n=41)	p-value
FEV1 (mL)	53.9±178.1	0.06
FEV1 (%)	0.5±122	0.54
FVC (mL)	−2.9±283.1	0.94
FVC (%)	−1.9±8.6	0.15
$FEF_{25–75}$ (mL)	225.3±452.2	0.02
$FEF_{25–75}$ (%)	10.3±19.7	0.02
ACT	2.1±2.6	<0.001

Note: All values are presented as mean ± standard deviation.

Discussion

Our study investigated breathing exercises as a non-pharmacological approach to controlling asthma. According to our results, the IS and control groups were similar in age, gender, and smoking characteristics. At the baseline visit, the IS group had lower FEV_1 and mL values, FVC percentage, and $FEF_{25–75}$ mL values than the control group. The baseline ACT scores were found to be similar.

At the control visit, FEV_1 mL and $FEF_{25–75}$ mL values were still lower in the IS group. No significant difference was observed between the two groups regarding ACT scores. When examining the changes between visits, the increase in FEV_1 mL was more pronounced in the IS group. On the other hand, the increase in ACT scores was more significant in the control group.

In the study group of 14 patients conducted by Rondinel et al, aiming to improve asthma control and quality of life, the gender distribution of the patients was found to be similar to our study. In contrast, the mean age was reported to be higher compared to our findings.[19] The difference in mean ages may be attributed to the small sample sizes in the studies and differences in ethnic and environmental factors.

Spirometry is one of the most essential tests in diagnosing and managing asthma. FEV_1 is the most commonly used spirometry parameter to demonstrate airway obstruction. An increase in FEV_1 is associated with a favorable treatment response, good prognosis, and well-controlled asthma. In our study, the IS group demonstrated a significantly more significant improvement in FEV1 values between the baseline and the second visit than the control group. When the IS

group's baseline and second-visit FEV_1 values were compared, an increase in FEV_1 was observed; however, the difference did not reach statistical significance. We believe that with an increased number of patients, a statistically significant improvement in FEV_1 values could also be observed within the IS group before and after treatment. Similarly, a study conducted in a pediatric asthma patient group demonstrated that manual diaphragmatic exercises significantly improved FEV_1 levels.[20] In another study evaluating COPD patients, inspiratory muscle training increased FEV1 levels.[21] We also think IS is an effective non-pharmacological treatment method positively contributing to asthma control.

Similarly, $FEF_{25–75}$ is a particularly significant parameter for diagnosing and evaluating asthma and small airway diseases. $FEF_{25–75}$ also known as the mid-expiratory flow rate, measures airflow during the middle portion of forced vital capacity and can more sensitively detect small airway obstruction.[22] In our study, evaluations performed before and after IS treatment showed a significant increase in. $FEF_{25–75}$ values in the IS group. When the results of an exercise program aimed at strengthening respiratory muscles through increased exercise were evaluated, it was observed that. $FEF_{25–75}$ values improved following respiratory exercises in patients with cystic fibrosis.[23] Additionally, a publication examining breathing techniques and yoga practices reported increased $FEF_{25–75}$ values after exercises in asymptomatic smokers.[24] The $FEF_{25–75}$ increase observed in our study may be associated with enhanced respiratory muscle strength and reduced small airway obstruction.

Incentive spirometry and spirometric assessment alone do not allow differentiation between the asthma phenotype, characterized by reversible bronchial narrowing and predominantly expiratory dyspnea, and clinically overlapping phenotypes such as paradoxical vocal fold motion, which involves reversible laryngeal narrowing and typically presents with inspiratory dyspnea. These phenotypes may share similar underlying endotypes and should therefore be considered in the differential diagnosis when interpreting the study findings.[25]

In addition, asthma symptom variability is strongly influenced by environmental allergen exposure, which may affect symptom burden and treatment response. Accordingly, accurate hypersensitivity assessment remains essential in asthma management, enabling appropriate allergen avoidance strategies and, when indicated, desensitizing immunotherapy. These aspects should be taken into account when evaluating the effects of non-pharmacological interventions such as incentive spirometry.[26]

The implementation of proper breathing techniques or respiratory physiotherapy has been shown in previous studies to reduce symptoms and improve the quality of life in respiratory diseases. For example, in a study by Santana et al evaluating the effectiveness of Iyengar yoga practice in patients with chronic respiratory disease, it was observed that after participating in the yoga program, patients reduced their respiratory rate, increased their tidal volume, and experienced a decrease in symptoms.[27] Also, it is shown that breathing retraining improves the quality of life, especially in uncontrolled patients.[28]

Aerobic or anaerobic exercises, which enhance respiratory muscle strength and overall muscle strength, are known to increase lung volumes, reduce the likelihood of flare-ups, and be safe, particularly in chronic obstructive pulmonary disease.[29] In a study examining the effects of exercises on asthma and bronchial hyperreactivity, it was observed that bronchial hyperreactivity was less common in the aerobic exercise group compared to the control group, flare-ups were less frequent, and quality of life survey scores showed an improvement.[30] The study by Rondinel et al showed that IS breathing exercises improved ACT scores and quality of life. However, no improvements in spirometry measurements were observed with the breathing exercises in that study.[19] The study by Thomas et al identified through Patient Reported Outcome Measures that breathing exercises improve the quality of life in asthma patients; however, no changes were observed in the physiological mechanisms.[31] In our study, we used the ACT to evaluate the effects of IS in daily practice. Improvements in ACT scores were observed in our study. On the other hand, an increase in ACT scores was also detected in the control group. This may be related to the recommendations provided during outpatient follow-ups and improved treatment adherence.

Techniques such as yoga and breathing exercises have been studied extensively in asthma; however, the application of IS in asthma remains underexplored.[32] IS has been widely investigated in COPD.[13] Moreover, studies on non-pharmacological respiratory physiotherapy techniques, including yoga and IS, have predominantly focused on conditions causing permanent respiratory problems, such as COPD, interstitial lung diseases, and pulmonary hypertension.[32] In

contrast, research evaluating these techniques in asthma is relatively limited. One of the strengths of our study is addressing this gap by specifically investigating the effects of IS in asthma, contributing valuable data to an area with limited prior research. Additionally, our study presents real-life data from a secondary care hospital in a region with a high prevalence of asthma. It involves a larger patient cohort than previous studies, further enhancing its significance.

Limitations

This study has several limitations. Incentive spirometry and spirometric assessment alone cannot distinguish the asthma phenotype from clinically overlapping conditions such as paradoxical vocal fold motion, which should be considered in the differential diagnosis. In addition, asthma symptoms may vary with environmental allergen exposure, potentially influencing treatment response.

The study was conducted at a single center, and patients were not randomized; however, participants were assigned sequentially to the intervention or control groups. These factors should be considered when interpreting the effects of incentive spirometry as a non-pharmacological intervention.

Conclusion

IS breathing exercises are less commonly used in asthma treatment than in COPD. Nevertheless, our study demonstrated significant improvements in ACT scores and spirometry parameters with their use. IS breathing exercises may be considered a method that enhances respiratory capacity, has no apparent side effects, and may be integrated into pharmacological or phenotype-based treatment approaches. However, to more clearly establish the efficacy of this method, further medical evidence from multicenter and double-blind studies is needed.

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Disclosure

The authors report no conflicts of interest in this study.

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