RESEARCH PAPER

Effect of Incentive Spirometry on Asthmatic Pregnant Women

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ABSTRACT

Background: Among the most prevalent chronic diseases that make pregnancy more difficult is asthma. Respiratory function alterations during pregnancy may interact with underlying asthma, leading to poor disease control and significant maternal and fetal morbidity. Therefore, this study was conducted to examine the impact of adding flow incentive spirometry to inhaled corticosteroid therapy in pregnant women with asthma to improve maternal outcomes. Methods: This study included 60 pregnant women, whose ages ranged from thirty to forty, and whose body mass indexes (BMIs) were between 25 and 29.9kg/m². One group was given budesonide (200-400 mcg twice day) as a medical treatment for 8 weeks; the other group served as a control, and the study group, which received sessions of the incentive spirometer 3 sessions per week for eight weeks. Assessment was done using spirometry to measure forced vital capacity (FVC) and ultrasound to evaluate diaphragmatic excursion before and after one and two months of the treatment. Results: no significant change ($p > 0.05$) was detected in both the control and study groups regarding the FVC and diaphragmatic excursion after one month of treatment. However, both groups showed a significant increase in FVC ($p=0.02$; $p=0.01$) and diaphragmatic excursion ($p=0.04$; $p=0.02$) after two months, respectively. At 1 month ($p=0.04$) as well as 2 months ($p=0.000$) after treatment, the study group had a statistically significant improvement in diaphragmatic excursion in comparison with the control group. Conclusion: The incentive spirometer is a safe, cheap, adjunctive method for increasing diaphragmatic excursion and maintaining FVC in pregnant women with asthma.

Keywords: Asthma, Pregnancy, Incentive spirometer, Forced vital capacity, Diaphragmatic excursion.

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INTRODUCTION

Among the most prevalent chronic diseases that make pregnancy more difficult is asthma, affecting approximately 4–8% of pregnant women [1]. It is characterised by recurrent episodes of wheezing, cough, chest tightness, in addition to dyspnoea, that frequently worsen at night or in the early morning. Asthma pathophysiology is multifactorial, involving interactions between environmental causes—including viral respiratory infections, airborne allergens—and host factors, including genetic predisposition and dysregulated innate immune responses [2].

Pregnancy exerts variable effects on asthma, with some women experiencing symptom exacerbation during the second and third trimesters, while others report improvement [3]. In pregnant women suffering from asthma, lung function may show modest longitudinal changes, including small reductions in forced expiratory volume in one second (FEV_1) as well as forced vital capacity (FVC) % predicted, reflecting physiological adaptations during gestation [4]. In asthma, FVC is generally preserved but may be reduced in severe asthma due to air trapping and poor disease control [5]. Additionally, asthma is associated with diaphragmatic dysfunction, as lung hyperinflation and altered respiratory mechanics can impair diaphragmatic efficiency and reduce lower-rib-cage expansion [6].

Maternal asthma is associated with clinically significant perinatal morbidity and mortality, adversely affecting both maternal and neonatal health-related quality of life. Preterm delivery, low birth weight, neonatal hospitalization, along with perinatal mortality are all associated with it [3]. Management of asthma during pregnancy relies on pharmacological approaches to control symptoms, prevent exacerbations, maintain near-normal lung function, minimize reliever use, and ensure optimal maternal quality of life and fetal development [7].

Chest physical therapy is an alternative strategy for reducing pulmonary complications. Incentive spirometry, a commonly used technique, includes a mechanical apparatus that offers visual cues to promote gradual, deep breathing, simulating the action of a natural sigh. Evidence suggests it enhances lung function [8] and decrease the risk of postoperative pulmonary complications [9]. Previous

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research has demonstrated the safety and feasibility of spirometry for longitudinal monitoring of lung function during pregnancy [10].

To the authors' knowledge, there is limited research data on investigating the use of non-drug strategies alongside standard medical care in pregnant women suffering from asthma that may enhance maternal outcomes. So, the study was done to investigate the impact of adding incentive spirometry to inhaled corticosteroid on FVC and diaphragmatic excursion in pregnant women having asthma. It is hypothesized that the beneficial effects would result from the combined treatment in pregnant women having asthma.

SUBJECTS, MATERIALS AND METHODS:

Subjects:

It was a prospective randomized study with a pretest-post-test design. Eighty pregnant women with asthma were referred by an obstetrician from El Sahel Teaching Hospital, Shubra. They were assessed as eligibility criteria. Their age ranged from 30 to 40 years, with BMI were between 25 and 29.9kg/m². They were in their first trimester of pregnancy; they were multiparous. They were diagnosed with asthma according to the General Diagnostic Basis for Asthma. Repeated episodes of wheezing, dyspnoea, chest tightness, and coughing were experienced by each subject. These symptoms varied over time and were most severe during the night or with triggers such as exercise, allergens, or respiratory infections. Some of the patients had FEV_1/FVC ratios that were lower than the lower limit of normal, indicating airflow obstruction. After the bronchodilator was given, there was significant enhancement in FEV_1 (≥12% and ≥200 mL), which means that the airflow restriction can be reversed. Additionally, they have a family history of asthma, along with exclusion of other causes of respiratory symptoms [11]. Participants were excluded if they had any uncontrolled diabetes mellitus or hypertension, neurological or neuromuscular disorders, cardiovascular instability, chronic chest disease, sepsis, severe anemia, or multiple pregnancies.

Twenty pregnant women were excluded; ten didn't fulfill the inclusion criteria, and another ten rejected to take part. Sixty women joined the study; they were allocated using a computer-generated random number into one of the two groups (control and study); each eligible pregnant woman with asthma was assigned a number from 1 to 60. The control group were given medical treatment in the form of budesonide, 200–400 mcg twice daily, and the study group received sessions of incentive spirometry three sessions per week for 8 weeks. All participants completed the study (Fig. 1).

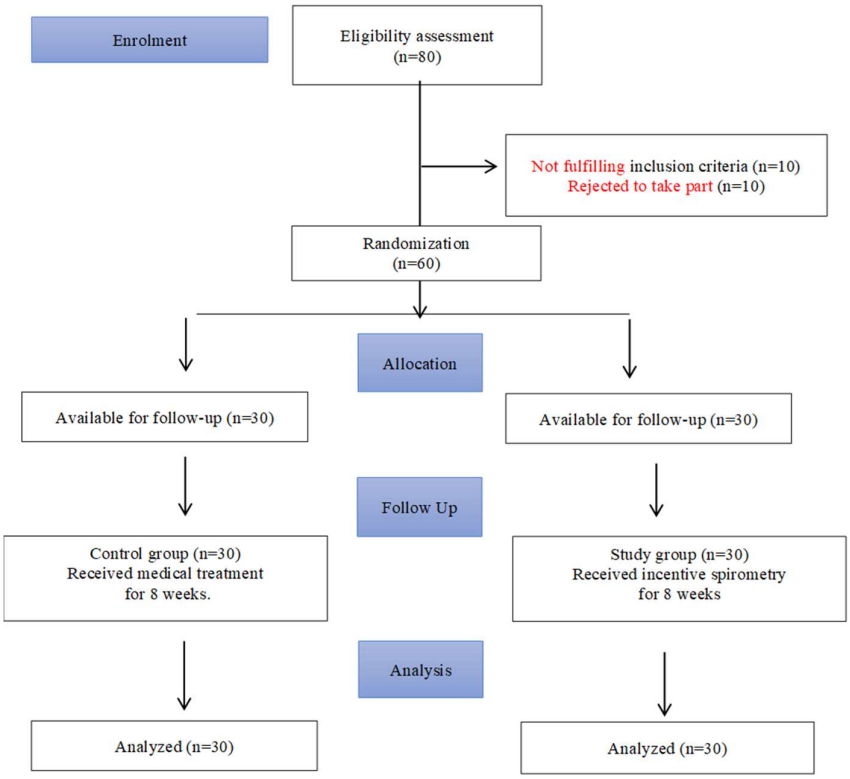

Fig. (1): Flow chart of the study.

The G*Power Software Version 3.1.9.7 was used to calculate the sample size. Vital capacity was the primary outcome. The effect size of 0.5 was calculated using the most appropriate data from a prior study [12] on the vital capacity assessed by an incentive spirometer, specifically the mean as well as standard deviation values. 0.05 was established as the alpha error of probability (α), and 0.67 was established as the power of the study (1-β error prob). A sample size of at least 60 was needed. Each patient was

given a thorough explanation of the study's protocol, purpose, nature, along with any risks involved before the initial assessment. Prior to enrolment along with participation, written informed consent was acquired. Both the study's center and the faculty of physical therapy at Cairo University's ethical committee of scientific research approved it (NCT05904002).

-Outcomes:

-Assessment of the forced vital capacity (FVC):

An incentive spirometer (SCHILLER SP-1, SCHILLER AG, Switzerland) was used to measure the FVC of each patient in the control and study groups at the start and after eight weeks of the treatment. It is widely accepted as a valid tool for evaluating pulmonary function. It provides consistent readings for repeated measurements under similar conditions [13]. It consists of a flow sensor/transducer, which is a white cylindrical mouthpiece section attached by cable; a main unit, which is the beige box with a keypad and display; a built-in printer; a digital display screen that shows real-time data; and a thermal printer. In a sitting position, each patient put her lips tightly around the mouthpiece tube and placed the soft nose clip around the nose to prevent air escaping through it. Then, she took the deepest breath possible and then exhaled into the sensor as hard and as long as possible. The indicator of the device numbers moved, referring to the value of the FVC. She repeated these procedures three times to be familiar with the device. Then, after an adequate rest, she performed three trials, and the average was taken.

-Assessment of diaphragmatic excursion:

Ultrasonography (Aloka Prosound 4000, Aloka, Japan) was used to evaluate diaphragmatic excursion in each patient in both groups at the start and after eight weeks of treatment. It is a valid and non-invasive tool that demonstrates high intra-observer and inter-observer reliability for measuring diaphragmatic excursion and thickness, providing an indirect measurement of respiratory function for each patient [14]. Diaphragmatic excursion was evaluated utilizing a real-time sonographic system (M-mode) using a 3.8 MHz convex probe at a depth of 22-24 cm. Each patient lay in a semi-recumbent (30–45°) position with her abdominal area uncovered. The radiologist set the device at 2–5 MHz and oriented the ultrasound sound beam at an angle of 45° to the cranio-caudal axis to optimize visualization while moving the ultrasound head in a gentle sweeping, fan-like motion. A cranio-caudal section was used to scan the diaphragm via the trans-subcostal area, following the right mid-clavicular line. The acoustic window for this imaging was the liver window. Diaphragmatic movement was assessed during both end-expiration and end-inspiration phases. A diaphragmatic excursion was determined by measuring the distance from the completion of expiration to the completion of inspiration relative to the position of the diaphragm's leading edge [15].

-Intervention:

1-Medical treatment:

Both groups received medical treatment in the form of Budesonide, 200–400 mcg twice daily, based on previous evidence indicating that corticosteroids inhaled are the best first-line treatment for asthma control during pregnancy due to their established safety profile and effectiveness in controlling symptoms and preventing exacerbations [16].

2-Incentive spirometer training:

The Triflow Incentive Spirometer (Tri-Ball Spirometer, Romsons, India) was used to apply breathing training for the study groups. It consists of a transparent plastic chamber containing three vertical air columns, each housing a lightweight-coloured ball, connected to a mouthpiece via flexible tubing. During inspiration, the balls rose according to the inspiratory flow and volume generated, providing visual feedback that motivated patients to achieve and maintain adequate inspiratory effort [17]. A commonly used incentive spirometry technique involved slow, deep inhalations with a breath-hold of 3–5 seconds at maximal inspiration to promote optimal lung expansion. Short rest periods of 30–60 seconds were taken between efforts to reduce fatigue or dizziness. Patients were encouraged to cough after several deep breaths to assist airway clearance. Each patient performed three supervised sessions per week for approximately 15 minutes and was instructed to perform these exercises ten times, twice daily at home [18].

-Statistical analysis:

The statistical software SPSS, Inc., Chicago, IL, version 25 for Windows, was used for screening the data for homogeneity of variance as well as normality assumption test. A normal distribution and homogeneity were seen in the data. The three measurements of each groups were compared using repeated-measures ANOVA. To further compare the pre- and post-treatment groups, an independent t-test was employed. A significance level of $p \leq 0.05$ was used.

-RESULTS:

At the beginning of this study, patients in both the control and study groups had similar baseline data, as shown in Table 1. Age (p=0.82), weight (p=0.76), height (p=0.47), and body mass index (p=0.70) were not significantly different across the groups in the independent t-test.

Table 1: Mean values of the baseline characteristics of the patients in the control and study groups.

Variable	Control group	Study group	t-value	p-value
Age (years)	46.85±2.6	45.90±2.85	1.20	0.82

Weight (kg)	93.80±12.75	92.75±8.90	0.30	0.76
Height (cm)	167.20±10.6	165.40±8.50	0.72	0.47
BMI (Kg/m^2)	33.30±1.55	33.90±1.60	1.22	0.70

Data was expressed as mean ± standard deviation; p: probability; BMI: body mass index.

Table 2. Comparison of forced vital capacity and diaphragmatic excursion for the control and study groups pre- and post-treatment

Variables	Time	Control group (n = 30)	Study group (n = 30)	p-value
Forced vital capacity	Pre-treatment	2.78 ±0.37	2.78 ±0.24	0.50
	One-month post-treatment	3.05 ± 0.23	3.06 ± 0.36	0.41
	Two-month post-treatment	3.42 ± 0.30	3.46 ± 0.33	0.30
	p-value	0.0000*	0.000*	
Diaphragmatic excursion	Pre-treatment	2.76 ±0.22	2.74 ±0.18	0.33
	One- month post-treatment	2.90 ± 0.20	2.99±0.22	0.04 *
	Two-month post-treatment	3.08 ± 0.21	3.31± 0.23	0.000*
	p-value	0.000*	0.000*	

*Data was expressed as mean ± standard deviation; p: probability; *p>0.05=significant.*

According to Table 2, the results of the repeated ANOVA demonstrated that the FVC significantly increased in both the control and study groups after treatment (p=0.0000 and p=0.000, respectively). Additionally, diaphragmatic excursion increased significantly (p=0.000) in both groups after treatment. The FVC was not significantly different between the groups before treatment (p = 0.50), one month after treatment (p = 0.41) or two months after treatment (p = 0.30). There was additionally no statistically significant difference before treatment (p = 0.33), however the study group demonstrated a significant enhancement after the first month (p = 0.04) and again after two months (p = 0.000) of treatment.

The results revealed that the FVC showed no significant change in the control group (p = 0.08) as well as the study group (p = 0.07) after one month of treatment with percentage changes of 9.71% and 10.07%, respectively. However, it showed a significant increase in the control group (p = 0.02) as well as the study group (p = 0.01) after two months of treatment, with percentage changes of 23.02% and 24.46%, respectively. However, it showed no significant change in the control group (p = 0.06) and a significant increase (p = 0.03) in the study group after two months, compared to one month after treatment with percentage changes of 12.31% and 13.07%, respectively.

Regarding the diaphragmatic excursion, it showed no significant difference in the control group (p = 0.14) and the study group (p = 0.07) after one month of treatment with percentage changes of 5.79% and 8.28%, respectively. There was a statistically significant improvement in both the control group (12.42% change) as well as the study group (20%) following months of treatment (p = 0.02, compared to p = 0.04, respectively). However, it showed no significant change in the control group (p = 0.11) and a significant increase (p = 0.04) in the study group after two months, compared to one month of treatment with percentage changes of 6.28% and 10.83%, respectively.

DISCUSSION:

Maintaining lung function, preventing asthma exacerbations, and reducing the risk of unfavourable maternal and foetal outcomes are all goals of effective asthma control during pregnancy [4]. Thus, the purpose of this study was to examine the impact of the addition of incentive spirometry to traditional medical treatment on lung function in pregnant asthmatic patients. The results revealed that FVC and diaphragmatic excursion improved following treatment with budesonide.

The findings are supported by a retrospective clinical study involving adults with cough-variant asthma treated with inhaled budesonide. It demonstrated significant improvements in pulmonary function, including increases in FEV_1, FVC, and peak expiratory flow (PEF). It also reported that the treatment was associated with enhanced lung function and reduced airway inflammation, accompanied by decline in serum levels of inflammatory along with allergic markers, such as tumor necrosis factor-alpha (TNF-α), interleukin-4 (IL-4), in addition to immunoglobulin E (IgE), suggesting an improvement in immune response [8].

Additionally, a prospective study using budesonide (200 µg twice daily) demonstrated significant improvements in several pulmonary function parameters over 8–12 weeks, including the FEV1/FVC ratio and mid-expiratory flow rates [19]. The observed improvements in lung function and airway inflammation in asthma are attributed to the suppression of eosinophilic inflammation, along with reductions in cytokine production and other inflammatory mediators, as well as decreased airway edema and mucus secretion [20, 21].

Patients receiving budesonide and spirometry sessions showed more improvement in diaphragmatic excursion without a change in the FVC than their controls. A previous study supported these findings, reporting no significant differences in FEV_1 and FVC among non-pregnant subjects with asthma who received incentive spirometer training for six weeks compared with a control group receiving no intervention. However, significant improvements were observed in small airway function and asthma control test scores [22]. Additionally, another study showed that participants who used flow incentive spirometry demonstrated improvements in their diaphragm excursion and FVC on the second day following laparoscopic abdominal surgery. They did not, however, experience any difference when compared to their counterparts receiving no treatment [12].

Other studies have also examined combined therapeutic approaches involving incentive spirometry. As an example, a study found that when standard asthma treatment was combined with incentive spirometry as well as expiratory positive airway pressure, both asthma control and quality of life were significantly improved compared to the control group that received standard care alone [23]. Similarly, another study found that both incentive spirometry and chest physiotherapy reduced asthma symptom recurrence and significantly improved FVC and FEV_1 compared with standard asthma management alone [24]. The contradiction in the results between studies may be attributed to the difference in the intervention applied.

An increase in diaphragmatic excursion without a corresponding increase in FVC in response to incentive respirometry suggests that diaphragmatic excursion can improve independent of FVC. One possible explanation is that diaphragmatic mobility is load-dependent whereby excursion can increase in response to greater respiratory effort or workload. This likely reflects improved diaphragmatic muscle activation and enhanced caudal displacement of the diaphragm during inspiration [25]. In contrast, forced FVC is a more complex pulmonary function parameter influenced by multiple physiological determinants, including airway resistance, lung compliance, and the degree of air trapping. These factors are particularly relevant in obstructive airway diseases such as asthma, where expiratory flow limitation may persist despite improved inspiratory muscle performance [26, 27].

STUDY LIMITATIONS :

The study results are limited to pregnant women in their first trimester. Therefore, more studies are needed to examine the long-term impact of the flow incentive spirometer on asthma during different trimesters of pregnancy. Further studies are needed to include a large sample size to validate the effectiveness of flow incentive spirometry on asthma during pregnancy. Also, comparative studies are required to investigate the impact of volume spirometry and flow spirometry on different age groups and asthma severity levels during pregnancy. Additionally, other lung function parameters, including FEV1 and PEF and functional parameters including dyspnea, daily functional capacity (ADLs), as well as quality of life measures, are warranted to be investigated in response to incentive spirometry in pregnant women suffering from asthma.

CONCLUSION:

Incentive spirometry is an effective adjunct modality for increasing diaphragmatic excursion and maintaining FVC in pregnant women with asthma.

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DISCLOSURE STATEMENT:

No author received any financial support for this research.

CONFLICT OF INTEREST:

The authors state no conflict of interest

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