

Effects of Home-based Incentive Spirometry on FEV1, FVC, 6-MWT, Control Status and Quality of Life of Asthma Patients

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Abstract

Rehabilitation management of Asthma patient, including breathing retraining that could be using incentive spirometry as biofeedback tool for patient when doing breathing exercise. The purpose of the research is to prove effect of home-based incentive spirometry (flow based) on FEV1, FVC, 6-MWT, asthma control status (ACT) and Quality of life (SGRQ) and spirometry test of asthma patient. This experimental study with Randomized Pre-test and Post-test Controlled Group design conducted at Dr Soetomo General Academic Hospital.

A total of 16 asthma patients aged 18-40 years were randomly and evenly divided into two groups. An exercise program using Incentive Spirometry (flow based) was given to the intervention group, whereas the control group doing diaphragmatic breathing exercises. Both workouts were performed at home for four weeks with frequency five times per day, each session has ten repetitions. Results indicates that exercise with home-based incentive spirometry (flow based) showed improvements in FVC parameters (p-value 0.009) large effect size (1.25), 6 MWT distance (p-value 0.005) large effect size (1.40); and activity score SGRQ (p-value 0.041) large effect size (0.8). Giving 4 weeks of home-based exercise with Incentive Spirometry-(flow-based) improves FVC, 6-MWT distance, and activity score of quality of life (SGRQ) in asthmatic patient.

Keywords: home-based Incentive Spirometry (flow based), asthma, FEV1, FVC, 6MWT, ACT, SGRQ.

1. Introduction

Asthma is one of ten major disease which causes morbidity and mortality in Indonesia, also made a great burden in the world, with the incidence 4.5 percent which is 4.6 percent in women and 4.4 percent in man (Kemenkes RI, 2014). In asthma there is hyperventilation marked by low arterial PaCO₂ and respiratory alkalosis (Courtney, 2017), due to hypertonicity of the respiratory muscles (Ritz et al., 2015), a tendency to pulmonary hyperinflation and impaired in thoracic breathing, irregular, paradoxal, and excessive sighing. Increased tone and activity of the inspiratory

muscles at the end of expiration increases lung inflation which changes the work pattern of the respiratory muscles to be shorter and weaker. This causes the loss of the appositional zone of the diaphragm, decreases inspiratory strength, and will increase the recruitment of accessory muscles of respiration in the neck and thorax (Decramer, 1997).

Asthma management attempts to improve and preserve quality of life so that patients can go about their daily lives without difficulty (Kepmenkes, 2008; GINA, 2019). This is accomplished by providing both pharmaceutical and non-pharmacological management, such as exercise. Breathing exercises for asthma patients are designed to normalized breathing patterns (breathing retraining), improve respiratory muscle strength and endurance, and improve chest wall flexibility and posture (Thomas and Bruton, 2014). The evidence on the advantages of breathing exercises for asthmatic patients is still equivocal, despite their widespread use (O Connor et al., 2015).

The technique of performing diaphragmatic breathing through a device with visual feedback based on the volume and flow of inspired air is known as Incentive Spirometry (Tyson, 2015). Incentive spirometry is similar to continuous maximal inspiration in that it is intended to simulate natural breathing and urge the patient to take deeper breaths.

This procedure reduces intrapleural pressure, expands the lungs, and improves gas exchange (AARC, 2011). Incentive spirometry is widely used as a prophylaxis for pulmonary complications in abdominal surgery (Tyson, 2015), Chronic Obstructive Pulmonary Disease (COPD) (Hoseini, 2016), and restrictive lung disease due to diaphragm or respiratory muscle dysfunction, such as in patients with spinal cord injuries. (SCI) (Mantri B, 2017) and as a breathing exercise aid for asthma patients at home (Mantri B, 2017).

Comparing with deep breathing exercises only (without support equipment), one of the advantages of Incentive Spirometry is that it is easy to monitor independently by trained patients, therefore it does not always require supervision (AACR, 2011). The goal of this study was to see how administering Incentive Spirometry as a breathing exercise assistance at home affected lung function metrics (FEV1 and FVC), functional capacity tested at 6-MWT, and asthma patients' quality of life.

2. Materials and Methods

This is an experimental study using Randomized Pretest and Posttest Controlled Group Design. A total of 16 asthma patients aged 18-40 years were randomly and evenly divided into two groups at Dr. Soetomo Surabaya's Asthma/COPD Polyclinic. Inclusion criteria were those who have been diagnosed with asthma and are controls at the Asthma Polyclinic and who have received instructions on their asthma treatment regimen for at least a month before starting the study, aged 18-40 years old, willing to follow the study protocol, and are able to understand the exercise procedure. We exclude subjects who had exacerbation within 24 hours prior to the test; breastfeeding or pregnancy; another pulmonary disease (tuberculosis, lung cancer, pneumonia, interstitial lung disease, pneumothoraks, bronkiektasis, bloody cough); another chronic comorbidity (heart disease, liver disease, kidney disease, diabetes mellitus, SLE, Rheumatoid Arthritis), any forms of cancer (Osteosarcoma, glioblastoma, breast, colon/rectum, ovary, melanoma maligna, prostate hyperthrophy). We drop out the subject if they skip the program for more than 7 days or more than 20 sessions during the periods; add another structured breathing exercise program; move to out of study coverage area; and at any kind of reason choose to stop following the study.

Before the trial, the subject conducted a physical examination, were informed about the study, and completed an informed consent form. The subject was then given basic information, asked to fill out questionnaires to assess asthma control status (ACT) and quality of life (SGRQ), and had 6-MWT and Spirometry tests done on them. The subjects were then randomly assigned to one of two research groups: An exercise program using Incentive Spirometry-(flow-based) was given to the intervention group, whereas the control group did diaphragmatic breathing exercises without the use of any instruments. For four weeks, both workouts were performed at home five times per day, each with ten repetitions. Every day, each subject completed the exercises according to what was taught at home, as indicated by the completion of an exercise monitoring card signed by a witness. Once a week, the subjects were contacted, reminded, and retaught the exercises. Patients were asked to complete the

questionnaire again at the conclusion of the fourth week to assess their asthma control status, quality of life (SGRQ), 6-MWT, and spirometry tests. The results are collected, and statistical analysis is performed. The findings of the analysis were thoroughly examined in order to draw inferences from them.

3. Results and Discussion

This study involved 19 patients who visited Asthma/COPD Pulmonary Polyclinic at Dr. Soetomo general academic hospital in Surabaya. For four weeks, research volunteers were randomly assigned to one of two groups: 10 persons in the intervention group and 9 people in the control group. Two subjects from the intervention group and one from the control group were removed from the study. One participant in the intervention group claimed that after following the exercise for two days withdrew from the trial due to chest discomfort; one other person was expelled for not being able to complete the exercise as scheduled. One participant in the control group said that she quit the study because his job environment had increased his activity, causing her to have frequent exacerbations (2 weeks early in the study of repeated exacerbations), and he moved outside the study's scope (outside the island). Six men and ten women were collected at the end of the study, divided into two groups of eight people each. This number still meets the required number of research subjects for each group, which is six individuals.

The Shapiro-Wilk test was performed to determine the normality of the research subjects' fundamental features. All data were normally distributed, and an independent parametric T-Test test was conducted across the two groups, with all initial parameters being equal (there was no difference between the two groups). Basic Characteristic of the subjects describe in table 1 and 2.

The results of this study revealed that no changes in all measures occurred before and after a 4-week home-based diaphragmatic breathing exercise. FEV1 (p-value 0.248), FVC (p-value 0.248), 6-MWT (p-value 0.115), ACT score (p-value 0.858), total score SGRQ (p-value 0.056), symptom score SGRQ (p-value 0.237), activity score SGRQ (p-value 0.366), and impact score SGRQ (p-value 0.366). (p-value 0.056).

Changes in asthma control status were assessed using the Asthma Control Test (ACT) questionnaire. According to the GINA recommendation, changes in asthma control status should be monitored monthly using the ACT questionnaire to measure the effect of medication on asthma control. This finding contradicts a study conducted by Grammatopapoulou et al. (2012) on breathing exercise in asthmatics, which found that after one month of exercise, asthma control status (ACT) improved significantly.

The findings of this study differ from those of Chung et al. (2021) and Majewski et al. (2015), who found that after 8 and 12 weeks of exercise, both breathing exercises with the Inspiratory Muscle Trainer device and breathing exercises without additional aids could improve the functional status of asthmatic patients, with no difference between the two interventions.

Exercises that improve the position of the diaphragm as it rises and falls during inspiration and expiration are known as diaphragmatic breathing. Deeper, slower breaths ensure that air is distributed evenly throughout the lungs. Slow breathing fills essential capacities, while holding the breath for 3-5 seconds allows the lungs to expand fully, opening the alveoli and increasing surfactant production. Diaphragmatic breathing exercises will also lessen the activity of accessory muscles of respiration, allowing for more typical breathing patterns and less breathing work (Grams et al., 2012). Diaphragmatic breathing exercises, according to Tahir et al. (1973), can enhance basal ventilation. Diaphragmatic breathing exercises, according to Weber and colleagues (1993), enhance tidal volume and facilitate fluid evacuation. Tactile stimulation above the lower rib cage, as well as verbal instructions, increased diaphragmatic movement during exercise, according to Blaney and Sawyer (1997). Diaphragmatic breathing exercises, according to Manzano et al. (2008), can enhance lung mechanics and, as a result, boost FVC. The lack of change before and after exercise could be related to the patient's inability to maintain good exercise technique when conducting the exercises at home alone.

Tabel 1. Subject characteristics

Profile	Control Group (n=8)	Intervention Group (n=8)	p-value
Age (Years)			
Mean \pm Standard Deviation	28,50 \pm 7,57	27 \pm 7,38	0,695
Min – Max	19-40	18-40	
BMI (kg/m ²)			
Mean \pm Standard Deviation	26,80 \pm 4,94	25,26 \pm 6,04	0,586
Min – Max	19.04-32.03	17.15-34.96	
Asthma Duration (years)			
Mean \pm Standard Deviation	10,75 \pm 6,86	15,00 \pm 10,47	0,353
Min – Max	2-19	1-33	
FEV1 (ml/s)			
Mean \pm Standard Deviation	2478,75 \pm 590	2167,50 \pm 465,97	0,261
Min – Max	1830-3360	1500-2710	
FVC (ml)			
Mean \pm Standard Deviation	3041,25 \pm 748,91	2708,75 \pm 527,18	0,322
Min – Max	2190-4190	2130-3530	
6-MWT (m)			
Mean \pm Standard Deviation	347,56 \pm 111,74	398,25 \pm 106,48	0,369
Min – Max	207-517.5	189-540	
ACT Score			
Mean \pm Standard Deviation	17,75 \pm 2,5	15,75 \pm 4,06	0,258
Well controlled (25)	0	0	
Partially controlled (20-24)	2	0	
Uncontrolled (\leq 19)	6	8	
Total SGRQ Score			
Mean \pm Standard Deviation	1594, 10 \pm 802,60	2041,60 \pm 982,36	0,335
Min – Max	157-2657.70	381.20-3389.70	
Symptom Score (SGRQ)			
Mean \pm Standard Deviation	279,26 \pm 148,5	378,15 \pm 102,3	0,143
Min – Max	86.8-505.40	219.40-525.40	
Activity score (SGRQ)			
Mean \pm Standard Deviation	642,23 \pm 308,05	665.1 \pm 391.47	0,898
Min – Max	0-985.80	0-1134.90	
Impact score (SGRQ)			
Mean \pm Standard Deviation	672.60 \pm 381.40	998.26 \pm 535.22	0,183
Min – Max	34.60-1229.60	161.80-1845-90	

Patients were told about the study orally at the start, written down on the monitoring card they took home, and shown with the trainer's help. Patients are urged to meet face-to-face once a week, either at the hospital or at their homes, to check probable side effects, exercise issues, and to remind them of proper technique. The patient also fills out the exercise column, which is confirmed by a member of the patient's family who has been designated as a home exercise supervisor in advance. The patient sits erect in an upright sitting position with the right hand on the epigastric and the left hand on the front chest during the workout. Movement occurs when inspiration is anticipated. The findings of this study can be used to provide an overview and assessment that the diaphragmatic breathing exercise technique with hands on the chest and belly, which is intended to be used as a home exercise program for asthma patients, is ineffective.

Exercise with home-based incentive spirometry-(flow-based) for 4 weeks improved the FVC parameter (p-value 0.009) with a large effect size (1.25), the distance before and after exercise (p-value 0.005) with a large effect size (1.40), and the activity score SGRQ (p-value 0.041) with a large effect size (1.40). (0.8).

The effect of strengthening inspiratory muscles on FEV1 and FVC in asthmatic patients has been debated in previous studies. This study's findings are like those of Chung et al. (2021), who compared inspiratory muscle strengthening exercises with weights on an Inspiratory Muscle Trainer (IMT) in asthma patients for 12 weeks 2 sessions per week, finding differences in FVC increase in the intervention group but failing to meet the MCID.

Chung et al. (2021) found that both groups improved their inspiratory muscular strength, as measured by an increase in maximal inspiratory pressure (PI Max), particularly the exercise group with BMI. According to the reference, the BMI exercise is identical to the Incentive Spirometry exercise in terms of respiratory phase, loading, and training goal, which is to improve the inspiratory muscles. The study found that FVC values improved significantly, which, while not clinically significant, could indicate an increase in inspiratory muscle strength

Table 2. Additional Profile of the Subjects

Profile	Total
Gender	
Male	6 (37.5%)
Female	10 (62.5%)
Allergic History	
Yes	13 (81.25%)
No	3 (18.75%)
Source of allergic	
Dust (including fur)	9 (56.25%)
Foods and drug	8 (50%)
Cold weather	3 (18.75%)
Occupation	
Housewife	2 (12.5%)
College students	4 (25%)
Student	1 (6.25%)
Worker	2 (12.5%)
Self-employed	7 (43.75%)

The 6-MWT gap between the intervention group and (flow-based) improved from an average of 347.56+111.74 to 452.825+100.281. (p-value 0.005). According to the findings of Chung et al. (2021), breathing exercises with the Inspiratory Muscle Trainer device can improve the functional status of asthmatic patients within 6 MWT. Majewski et al. (2015) also suggested that breathing exercises with the Inspiratory Muscle Trainer device can improve the functional status of asthmatic patients.

Incentive Spirometry device is based on the volume of inspiration (volume-oriented) or airflow (airflow-oriented) (Flow- oriented). The Incentive Spirometry-(flow-based) system consists of three chambers, each with a sphere. The ball will be elevated in its chambers if the patient applies sub-atmospheric pressure on it. Lifting the first ball requires a 600 mL/s inspiratory flow, lifting the first and second balls requires 900 mL/s, and lifting the complete ball requires 1200 mL/s. The volume-oriented incentive spirometer is a collection of devices with a capacity of up to 4000 mL and a one-way valve that prevents expiration. The amount of inspiratory volume and flow that can lead the subject to inhale gently is indicated. Incentive spirometry is used to help patients inflate their lungs to their maximum capacity and maintain that expansion. This maximum lung expansion is supposed to be able to open the collapsed alveoli, preventing the atelectasis from being overcome. During inspiration, maximum lung expansion raises transpulmonary pressure. Re-inflation of alveoli keeps them inflated during expiration, enhancing the lung's functional capacity (Ho et al., 2000).

The findings of this study contradict those of Nikmah et al. (2014), who found that utilizing Incentive Spirometry considerably improved lung function (FEV1), otherwise was similar result for measures of functional status (6-MWT distance), and quality of life in asthmatic patients (SGRQ). There are some discrepancies with this research. First, a volume-based incentive spirometer was used in the study. Second, a longer period of exercise is required (8 weeks) and the subject was asthmatic patients with allergic bronchial asthma.

Table 3. Inter and Intra-Group Analysis

Variable		Control/ Diaphragmatic breathing (n=8) (Mean+ SD)	Intervention/ Incentive Spirometry (n=8) (Mean+ SD)	p-value (T- test Independent)
FEV1 (ml)	Pre-test	2167.50±465.97	2478.75±590.7	0,261
	Post-test	2061.25±383.60	2620±640.2	0,053
	Paired t-test	0,248	0,192	
	Difference Pre and Post test	106,25±283,44	-141,25±276,94	0,076
	%	3,74	-6,13	
FVC (ml)	Pre-test	2708,75±527,18	3041,25±748,91	0,322
	Post-test	2690.00±471.835	3331.25±658.297	0,042*
	Paired t-test	0,927	0,009*	
	Difference Pre and Post test	18,75±556,29	-290±231,82	0,169
	%	-1,50	-10,86	
6-MWT (m)	Pre-test	398,25±106,48	347,56±111,74	0,369
	Post-test	438.750±52.0913	452.825±100.2817	0,730
	Paired t-test	0,115	0,005*	
	Difference Pre and Post test	- 40,5±71,91	-105,26±74,72	0,099
	%	-17,5	-37,6	
ACT Score	Pre-test	15,75±4,06	17,75±2,5	0,258
	Post-test	17.00±5.071	17.75±3.694	0,740
	Paired t-test	0,858	1,000	
	Difference Pre and Post test	-1,25±6,73	0±2,72	0,634
	%	-20,9	0,07	
Total SGRQ Score	Pre-test	2041,60±982.36	1594, 10±802,60	0,335
	Post-test	1725.32±881.98	1243.92±863.92	0,289
	Paired t-test	0,056	0,094	
	Difference Pre and Post test	316,27±390,89	350, 17±511,22	0,884
	%	20,7	28,17	
Symptom Score (SGRQ)	Pre-test	378,15± 102,3	279,26±148,5	0,303
	Post-test	313,7±154,63	235,80±153,43	0,329
	Paired t-test	0,252	0,304	
	Difference Pre and Post test	64,65±140,87	43,46±110,7	0,745
	%	15,34	21,78	
Activity score (SGRQ)	Pre-test	665.1±391.47	642,23±308,05	0,898
	Post-test	600.62±403.82	415,31±277.39	0,303
	Paired t-test	0,366	0,041*	
	Difference Pre and Post test	64,56±198,1	226,92±256,56	0,172
	%	10,61	32,66	
Impact score (SGRQ)	Pre-test	998.26±535.22	672.60±381.40	0,183
	Post-test	811.00±448.80	592.81±489.40	0,368
	Paired t-test	0,056	0,422	
	Difference Pre and Post test	187,26±231,8	79,78±264,7	0,402
	%	24,98	27,47	

Improvements in diaphragmatic muscle strength may be the mechanism of improvement in lung function (FVC), functional status (6-MWT), and quality of life (SGRQ) identified in the intervention group of this study. Deep and slow breathing exercises with Incentive Spirometry are performed with an instrument that provides visual feedback. This feedback could help patients monitor their exercise skills at home and provide more motivation than unassisted diaphragmatic workouts. Flow-based and volume-based incentive spirometers have different physiological effects. Flow-oriented incentive spirometry encourages increased respiratory effort and upper-chest muscular performance. The Coach-2 gadget (volume-oriented), requires less breathing effort and

enhances diaphragmatic activity. When comparing the effects of diaphragmatic breathing, flow, and volume-based Incentive Spirometry on diaphragmatic excursions and lung function in post-laparoscopic patients, Alaparthi and his team (2016) found that diaphragmatic breathing and volume-based Incentive Spirometry exercises significantly prevent lung function decline as measured by FVC. To date, there are no studies that compare the effectiveness of utilizing flow-based and volume-based Incentive Spirometry for asthmatic patients.

There were four minor adverse events recorded during the research, and no major adverse events. In the intervention group, one moderate adverse event was observed, while three incidents were reported in the control group. One occurrence in the intervention group was the start of chest tightness, which made the participant fearful of an exacerbation. Finally, the participant withdrew from the research. A few days later, a follow-up exam revealed that the soreness had subsided and had returned to normal. Exacerbations rose in the first control group of subjects because of increased activity at work. This exacerbation can be treated with a medication that the patient already has on hand. Subjects finally dropped out of the study because they strayed too far from its parameters. Another individual complained of exhaustion; it was later discovered that the subject had performed the exercise more frequently and for longer than the required number of repetitions. Re-education was given, and the subject followed the study's instructions, resulting in the patient's condition improving once more. After exercise, another person in the control group complained of heartburn and nausea. One subject of diaphragmatic breathing exercise pressing the abdomen strongly in the hope of providing greater resistance to the decrease in the diaphragm. The patient improved after being re-educated on the technical training and continued the exercise program until it was completed. Neither group experienced any major adverse events during the research.

Incentive Spirometry-(flow-based) is the most widely utilized complement to respiratory rehabilitation programs in the hospital where the study was conducted, and it is available in pharmacies and hospitals at a reasonable price.

This study has several limitations including: 1) The research technique is not blinded. The same researchers randomized the participants, observed the exercise program's progress, and collected data following the exercise time. 2) Outside of the exercise program, physical activity and allergen exposure of research subjects could not be controlled, even though participants had been instructed not to participate in other structured physical exercise programs and to prevent allergy exposure during the study. There are still variables beyond the researcher's control that can affect the patient's control status and quality of life. The family witnesses the patient's compliance with the exercise regimen, which is recorded on a monitoring card filled out by the patient himself. Video calls, phone conversations, and house visits were also used to monitor the situation. Aside from that, this research method has disadvantages in terms of ensuring that the patient performs the activity correctly and obediently. 3) After the patient had exercised for a longer period of time, no monitoring or follow-up was done, therefore the additional improvement effects that came after a longer period of exercise were not documented. 4) Other metrics that directly reflect muscular strength improvement, such as PI max and/or biofeedback, were not measured in this study.

Conclusion

We may conclude from the findings of this study that providing asthmatics with home-based exercise using Incentive Spirometry-(flow-based) influences raising FVC (p 0.009), 6-MWT distance (p 0.005), and activity score of quality of life (SGRQ) (p 0.041).

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