Original Article

Active Cycle Of Breathing With Postural Drainage Versus Auto Genic Drainage On Airway Resistance In Chronic Obstructive Pulmonary Disease

Mahmoud Ahmed Labib[1], Badr Al-Amir Hassan[2], Nesma A. Helmy[3], Hany Hussein Mohamed Moussa[4], Hany Ezzat Obeya[5]

1 Department of Physical Therapy for Cardiovascular/Respiratory Disorder and Geriatrics, Faculty of Physical Therapy, Kafr El Sheikh University, Egypt

2 Lecturer of Physical Therapy Department of Physical Therapy for Internal Medicine and geriatrics, Faculty of Physical Therapy, Delta University.

3 Lecturer, Basic Science Department Faulty of Physical Therapy Beni-Suef University.

4 Lecture of Chest Faulty of Medicine Kafr Elsheikh University

5 Department of Physical Therapy for Cardiovascular/Respiratory Disorder and Geriatrics, Faculty of Physical Therapy, Cairo University, Egypt

Corresponding author: Mahmoud Ahmed Labib

Email: ptrservices2022@gmail.com

DOI: 10.47750/pnr.2022.13.S07.559

Abstract

This study was conducted to compare efficiency of two air way clearance techniques on air way resistance in COPD patients. It is all about the usage of impulse Oscillometry to follow the impact of various pulmonary rehabilitation procedures (postural drainage, active cycle of breathing and auto genic drainage) on airway smooth muscle resistance in COPD patients. Thirty COPD patients, ranging in age from 50 to 60, were chosen in the current study. All of the patients were informed about the study's fundamental scope before starting the treatment. It was a comparative study, thirty patients with C.O.P.D. are involved, subjects divided into two groups A and B, Group A received active cycle of breathing technique in addition to postural drainage, Group B received autogenic drainage. We have shown that there are no significant results between active cycle of breathing in addition to postural drainage and autogenic drainage on air way resistance in COPD patients, in this study active cycle of breathing techniques with postural drainage and autogenic drainage are efficient separately on air way resistance but when compared there is no substantial difference among the two groups.

INTRODUCTION

Non-reversible airway obstruction is a characteristic of COPD. This is caused by a mixture of airway wall remodeling-induced narrowing and collapse in expiration due to lack of alveolar attachments as well as elastic recoil at the appearance of small airways, with these two manifestations mixed in varying proportions in actual COPD cases.

COPD is a primary reason for illness and mortality. Its existence is predicted to climb rather than a decline in the coming years. Patients with COPD commonly experience incapacitating breathlessness and reduced functional capacity. Physiotherapy's role in the care of COPD includes addressing concerns such as lowering work of breathing, boosting clearance airway, enhancing mobility, encouraging rehabilitation, and helping to providing a suitable noninvasive ventilation management (1).

Patients with COPD commonly complain of incapacitating dyspnea and a loss of functional abilities. Physiotherapy's role in the care of COPD includes addressing concerns about lowering work of breathing, boosting clearance airway, enhancing mobility, encouraging rehabilitation, and helping to providing a suitable noninvasive ventilation management.

Chest physical therapy (CPT) is considered a common technique used in the treatment process of airway disorders, according to Cees, 2007(2). The major objectives are to enhance mucus clearance, decrease the risk of lung infection, halt pulmonary and function deterioration. In stable patients with COPD, conventional CPT is used to prevent problems during the perioperative period, as well as in some critically ill patients.

Respiratory disorders are symptoms of chronic obstructive pulmonary disease. Lung tissue/ elasticity loss will eventually lead to a further reduction in lung function and respiratory failure. The disease has a systemic component, which includes systemic inflammation, muscle mass, and other comorbidities (3).

Evaluating the mechanical impedance of the respiratory system for assessing airflow blockage has been reported using impulse oscillometry, a simple non-invasive technique. An impulse oscillometry system (IOS) is now commercially available and does not require the patient's active participation. The efficacy of this approach has already been demonstrated in children and non-cooperative patients when compared to spirometry. Despite this, there are few adult impulse oscillometry studies (4).

The impulse oscillometry approach is becoming more common in lung function tests because it only requires the subject's passive help in the form of silent tidal breathing. Because it does not produce respiratory exhaustion, IOS is therefore ideal for repeated measurements (5).

Furthermore, Impulse oscillometry is a non-effortful assessment that can be used on children or the elderly who have difficulty performing a forced expiratory maneuver. IOS also offers the advantage of being able to distinguish the central and peripheral components of respiratory impedance. It's important to remember that R5 and R5-R20 aren't the same as central and peripheral airway resistance. Both parameters take into account the influence of lung tissue, chest wall impedance, and ventilation inhomogeneity (6).

Breath regulation, thoracic expansion techniques, as well as forced expiration procedures are the three components of the active cycle breathing technique (ACBT), as defined by Angshu, and Colleges in 2009 (7). (1 or 2 huffs accompanied with periods of breathing control). Secretions within the more distant airways can be expelled by huffing to low lung volumes, while those in the closer airways can be expelled by huffing or coughing from a high lung volume.

Autogenic drainage (AD) is a well-known airway clearance technique (ACT) for clearing the airways of secretions with deep inhalations and only mild exhalations. As patient exhale, patient should be able to hear and feel the secretions, and patient should resist the need to cough till the secretions are high enough that patient can get at them with little effort (8). The procedure has been demonstrated to cause sustained airflow that is greater than typical in the airways of the lungs, affecting the lungs and making deep breathing as well as coughing hard, as well as thick mucus collecting in the patient's lungs due to the pain from the incisions as well as the stitches. Session-based AD has been shown to be superior to preexisting modes of pulmonary as well as cardiac diaphragmatic breathing in mobilizing secretions under a variety of situations (2). To facilitate AD, practitioners typically sit. The principles can be taught in 10-20 hours, broken up into 30-45 minute lessons twice a day (8). The process requires multiple levels of concentration, which would be too much for children below the age of eight.

By opening up the airways through the use of AD, mucus can be expelled more easily and breathing can be made easier (8). Although Chevaillier developed this theory in1960s in Belgium, not much was written concerning it until 1979. (9).

Huffs with a moderate to low lung capacity are alternated with deep breaths as well as relaxed abdominal breathing in what is called the active cycle of breathing (ACB) (10).

Unstick, gather, and expel are the three steps outlined by Chevaitlier. It is believed that mobilizing peripheral mucus by breathing with a decreased lung capacity. We've entered the first, "unstick," stage. It is then followed by tidal breathing, that helps clear the airways of mucus. The secretions in the central airways are then encouraged to be expectorated by breathing with larger lung volumes during the evacuate phase. Clearing the trachea of secretions may need a puff from a large volume of lungs (11). It's not encouraged that you cough.

Delimitation:

This study was delimited to the following:

1- Thirty males between the ages of 50 and 60 were diagnosed with COPD after experiencing coughing and sputum production for at least 3 months each year for at least 2 years, as well as dyspnea, wheezing, and spirometric obstruction.

2- Measure airway smooth muscle resistance by Impulse Oscillometry pre-and-post the treatment process.

Limitations:

Patients with:

- Short-acting bronchodilator reversibility.
- Allergic rhinitis, atopy, or asthma.
- Current airway infection.
- Any medical complications excluding COPD.
- acute Myocardial infarction.
- Cases of congestive heart failure or cardiac arrhythmia.
- History of Lung cancer.
- History of neuromuscular disorder if the patient could not assume a sitting position.

MATERIALS AND METHODS

Researchers used IOS to look at the effects of different chest physical therapy modalities on airway smooth muscle resistance in COPD cases.

I) Subjects

Thirty COPD patients, ranging in age from 50 to 60, took part in the study. The participants were categorized into 2 groups of equal number according to the following criteria; (A) and (B).

Inclusion criteria:

1- COPD men patient.
2- Ages of the participants were ranged from

   50 – 60 years old.
3- COPD patients were defined by coughing and sputum synthesis for at least 3 months a year for a couple of years or more, dyspnea, and spirometric obstruction.

Exclusion criteria:

1- Short-acting bronchodilator reversibility.
2- Allergic rhinitis, atopy, or asthma.
3- Current airway infection.
4- Any medical complications other than COPD.
5- Recent Myocardial infarction.
6- Cases of Heart failure or cardiac arrhythmia.
7- History of Lung cancer.
8- History of neuromuscular disorder if the patient could not assume a sitting position.

II) Instrumentation

Assessment instrumentation

Impulse Oscillometry: It is used to measure airway resistance, IOS will determine the airway resistance response to various chest physiotherapy techniques. Jaeger's Master Screen Impulse Oscillometry device will be used (Jaeger, Med Point Technology, Inc., Millbury, oh, LAB manager software version 4.53.2, 2002), While taking into account the manufacturer’s recommendations.

III) Procedure:

(1) Evaluation Procedure

Before starting the evaluation procedure, a complete explanation was given to each patient in the two groups about what would going to be done.

The evaluation was performed for the participants of the 2 groups before and after the treatment procedures

Patients were asked to stand upright, clip their noses, and hold their cheeks among hands for the duration of the measurement. They clamped their lips over the mouthpiece and also kept their tongues in their cheeks to block off artefacts. After the patients had established normal spontaneous tidal breathing for around 60 seconds, the measurements began.

(2) Treatment procedure:

Before starting the treatment session, a complete explanation was given to each patient in the two groups about what would going to be done.

Group A:

- **Active Cycle of Breathing Technique:**

Patients take up their preferred position. Although most people do this while sitting, some people find certain postural drainage positions, such as alternate side-lying, are beneficial. Patients should be shown the following sequence while sitting in front of them:

1- One-minute practice of controlled, deep abdominal breathing (breathing control) to help you relax.
2- Take three to four breathing exercises (thoracic expansion) to expand collateral airways and restore airflow for thirty seconds. Relaxed abdominal breathing, to maintain relaxation for about 1 minute.
3- One or two huffs to mobilize secretions, starting with a low lung capacity.
4- Performing 1–2 minutes of respiratory control exercises before resuming the cycle. Gentle breathing using the lower chest at appropriate tidal volumes and a natural rate with unforced expiration is required for effective breathing control.
5- The cycles are repeated until the patient's tolerance is reached or the mucus congestion has gone. However, till the chest is subjectively or objectively free of secretion, or the patient fatigued, a minimum of 3 to 4 cycles is indicated.

- **Postural Drainage:**

Patients were positioned in a relaxed position with the area to be drained on top, with the understanding that these positions may have to be accustomed for the patient to be comfortable. To prevent infected secretions from overflowing into the healthy lung, the most afflicted area is drained first. Before, during, and after PD, patients have to be monitored for arrhythmias or desaturation.

- **Breathing Control Technique:**

Breathing control means breathing from the abdomen with a normal tidal volume.

1- The patient should settle into a balanced position, like upright sitting. Without using phrases like push, pull, try, or harder, the maneuver is first taught and shown slowly. If the patient's calm abdominal breathing hasn't started on its own, the following steps are performed.

2- Allow the patient’s dominant hand to rest on his abdomen, elbows supported, and elevate slowly while seeing air getting into his abdomen similar to a balloon, while keeping his shoulders relaxed.
3- Teach the patient how to breathe with pursed lips by inhaling through the nose and exhaling through the mouth despite the resistance created by the pursed lips.
4- Shoulders have to remain relaxed and heavy.
5- Gradually deepen the breathing while remaining relaxed, and exhale through pursed lips.
6- Progression: side-lying as well as relaxed standing if necessary.

Group B: Auto genic drainage:

Patients take up their preferred position. Although most people do this while sitting.

Phase 1: Moving the mucus from the small airways (unsticking) the patients were asked to start with breathing control (air in, air out) then relax. Then patients were asked to take in a deep breath and blow all of the air out of their lungs until patients feel like the lungs are empty of air.

Once the lungs are empty, the patients were asked to take in a small breath of air through their nose.

Then patients were asked to hold the breath for three seconds then exhale all of the air out.

Repeat this two times.

Phase 2: Moving mucus from the small airways to the medium – sized airways (collecting)

The patients were asked to:

- Take in a normal sized breath.

Hold the breath from three seconds.

With some gentle force, the patients exhale all of the air out of their lungs.

Repeat three times.

Phase 3: Moving mucus from the medium – sized airways to the large airways to be coughed out (evacuation) the patients were asked to take in a deep breath.

Hold for three seconds.
With gentle force, exhale all of the air out of their lungs.

Repeat three times.

Asked the patient

Do not cough until after the third breath.

Each phase take two to three minutes to complete. Completing all three phases (one cycle) take about six to nine minutes to complete. Repeat the cycle until the patients cleared their lungs as much as possible, which take between 20 and 45 minutes.

RESULTS

This study enlisted the help of thirty COPD patients between the ages of 50 and 60. COPD patients were identified cough as well as sputum production for 3 months each year for a couple of years or more, dyspnea, wheezing, and the presence of spirometric obstruction. The patients were categorized into two groups as shown below:
Group A: contained fifteen participants who have received active cycle of breathing technique in addition to postural drainage.

Group B: Has fifteen subjects who have obtained autogenic drainage**.**

Table (1): Statistical analysis for the value of ANOVAs test for Airway resistance at 5 Hz (total resistance) post the treatment process.

Variables	Before	After	Significance
Group (A)	**245 ± 16.2**	**239± 16.5**	**S**
Group (B)	**248± 14.5**	**241±13.8**	
P value	**0.541**	**0.68**	**NS**

Significance Indication at P<0.05. * = significant. ** = nonsignificant

Table (2): Statistical examination of the change in airway resistance at 20 Hz (central resistance) after the treatment program using ANOVAs test.

Variables	Before	After	Significance
Group (A)	**125±14.6**	**124±14.4**	**S**
Group (B)	**124±12.5**	**123±12.1**	
P value	**0.817**	**0.813**	**NS**

Level of significance at P<0.05. * = significant. ** = nonsignificant

Table (3): highlights the statistical analysis for the ANOVAs test value for the of change of Airway resistance at R5–R20 Hz (peripheral resistance) after the treatment program

Variables	Before	After	Significance
Group (A)	115.3±23.6	110±23.4	S
Group (B)	11.7±20.5	107±21.3	
P value	0.712	0.674	NS

Level of significance at P<0.05. * = significant. ** = nonsignificant

DISCUSSION

COPD patients are often recommended to participate in chest physiotherapy. various studies have examined how chest physiotherapy helps patients with COPD by measuring their airway resistance. Nevertheless, it has not been clearly differentiated which methods of chest physiotherapy are more effective at reducing airway resistance in patients with COPD. The purpose of this study was to evaluate the efficacy of various chest physiotherapy interventions for reducing airway resistance in patients with COPD.

Patients with COPD are often advised to do chest physiotherapy. Several researches have looked into the impact of chest physiotherapy on COPD patients' airway resistance. However, the benefits of various methods of chest physiotherapy on COPD patients' airway resistance have not been properly separated. As for the objective of the current study, it is all about assessing the outcomes of adopting various types of chest physiotherapy on COPD cases.

The measures in this study were airway resistance at 5 Hz (Total resistance), 20Hz (Central resistance) and 5 Hz-20 Hz (peripheral resistance).

On one level IOS was utilized by researchers to examine the effects of various chest physical therapy modalities on airway smooth muscle resistance in COPD patients. The psychological implications of the chronic obstructive pulmonary disease include health status, dyspnea, anxiety, and sadness (COPD). The Global Initiative for Chronic Obstructive Lung Disease (GOLD) lists improved health status and symptom reduction as successful management goals (12).

On the other level, Physiotherapists are also well-known for their contributions to the treatment of people with respiratory illnesses. They employ a range of techniques to minimize breathing effort, improve ventilation, improve function, and treat dyspnea (13). One of the key pathophysiological characteristics of COPD is small airway illness (obstructive bronchiolitis). COPD patients develop hyperinflation as a result of peripheral airway restriction, which restrict air throughout expiration.

Furthermore, **Al-Mutairi et al.** (14) discovered that IOS has a higher diagnostic sensitivity (31.3 %) than conventional pulmonary function tests (19.6 %), whereas in cases of COPD, spirometry has a higher sensitivity (47.4 %) greater than IOS (39.0 %), and the specificity for IOS and spirometry in asthma as well as COPD was comparable.

In 1967, Chevaillier developed AD in Belgium as a means of helping those suffering from COPD. In a, relaxed state, practice AD through quiet expirations without adopting any of the traditional postural drainage positions. Excluding preexisting lung as well as cardiac diaphragmatic breathing, AD utilises session to mobilise secretions through different circumstances of expiratory airflow (14).

This study's findings should be confirmed, and it's important to consider the impact of autogenic drainage on lung volume, expiratory flow, as well as dynamic airway compression given that so much previous work with AD has targeted on patients suffering from COPD. Patients with low lung recoil pressure require special precautions during expiration to prevent airway collapse (15).

AD Rather than employing forced expiration to improve airflow velocity, they will instead adjust the volume of air in their lungs. Comparison of the flow-volume curves throughout AD and forced expiration reveals that AD's unforced breathing is more effective at clearing the airways of secretions (16).

Without using forceful expirations, which can cause airway closure, AD exercises can help transfer secretions from the periphery to the center of the airways. There are three different phases of breathing exercises. Collateral filling within the alveoli may have facilitated ventilation and mobilised secretions as individuals gradually increased their inspiratory as well as expiratory reserve volumes from functional residual capacity and a 2–3 second breath-holding time.

So, at the session's end, all patients take a deep breath and force the mucus out. throughout a huff, the airway pressure (intraluminal pressure) drops from the periphery to the mouth as a result of frictional pressure drop and the lack of convective acceleration pressure (17). There's a possibility that huffs will begin at larger lung volumes (deeper into the inspiratory reserve volume) and then shift to larger lung volumes (deeper into the expiratory reserve volume) during the course of the event (but probably not as deep as the 1st midlevel huffs) (18).

On the other hand, the findings of this study was contradicted by the work of **Giles et al.,** (19) who discovered a minor but statistical substantial desaturation with (PD) and also percussion and a minor but substantial improvement in saturation with AD. They also discovered that no substantial difference in pulmonary function test parameters.

Despite **Wollmer et al.** (20) showed that chest percussion added to an airway clearance approach increased airflow obstruction, **Gallon** (21) observed that chest percussion did not raise airflow obstruction. **Falk et al.** found that chest percussion also increases hypoxemia. (22)**.**

On the contrary, **Savci et al,** (23) study the effect of ACBT over 20 days period in patients with COPD. They found that ACBT improved FVC, PaO_2, SaO_2 and exercise performance that agree with the results of this study which confirm that ACBT as a useful chest physiotherapy method in reducing airway smooth muscle resistance.

The findings of this study can be explained by the work of **Pryor et al.,** (24) who found that there is no sign of any rise in airflow obstruction nor oxygen desaturation when using ACBT with asthmatic patients. These results came in line with our results.

The results achieved in this study are in agreement with that achieved in the work of **Savci et al.,** (25) who identified improvements in pulmonary functions, arterial blood gases exercise tolerance and dyspnea scores when using ACBT.

By employing the ACBT, Pryor et al. (26) were able to avoid the desaturation seen with TP alone by performing 3 to 4 thoracic expansion procedures in between TP episodes.

The ACBT is a three-stage breathing technique that uses an active cycle. This is the initial stage, where your airways are relaxed. Phase two, which assists in breaking through mucus barriers and allowing air through. Mucus is expelled from the lungs with the assistance of the third phase. Maintaining Regulated Breathing: Reducing tension in the airways is possible through conscious breathing. Inspiration is through thought the nose while expiration is through the mouth requires no effort. Calm, normal breathing from the lower chest, with the shoulders and upper chest relaxed. chest expansion exercises: Take a deep inspiration in, and then slowly expire it out without straining. Clapping or vibrating the chest may be used for this, accompanied by regulating the breath. Huffing of coughing, also known as the forceful expiratory technique, involves coughing for varying but consistently long durations in order to propel mucus into the upper airways. To completely clear the larger airways of mucus, you should repeat this huffing process several times.

According to Patterson et al. (27), the ACBT is an efficient airway clearing strategy for the treatment of bronchiectasis, allowing for the removal of secretions and the enhancement of lung function. The patient as well as physiotherapist can decide which method is best for a patient with stable COPD.

Autogenic drainage as well as Active cycle breathing technique were found to be beneficial in clearing mucus, a common source of airway blockage in COPD patients, by Patterson et al. (28). This was shown by enhancement in lung function testing.

Among the leading causes of morbidity as well as mortality, COPD deserves special attention. Ten % of those older than 40 years old in the general population have COPD. It's the 4th leading reason of death around the world. Airflow obstruction caused by COPD pulmonary diseases is sometimes reversible. Patients with COPD often experience severe dyspnea, diminished functional capacity, as well as acute exacerbations. (29).

Treatment of airway clearing is achieved by utilizing the ACBT, which involves breath holding, chest expansion exercises, as well as huffing (30). This method improves diaphragmatic function while breathing, builds diaphragmatic strength, and decrease the work of breathing by slowing the breathing rate and decreasing oxygen consumption (31).

Only a select few studies have shown that ACBT is effective in enhancing lung function, arterial blood gases exchange, exercise tolerance, as well as dyspnea (32). Clearing of lung fields and enhancement of pulmonary function in patients with bronchiectasis have both been shown to be effective with ACBT, and these findings have been confirmed by numerous studies (33).

Twenty stable COPD patients, mostly those with bronchiectasis, participated in a randomized crossover trial using ACBT and the test of progressive respiratory endurance (27). Airway clearing in bronchiectasis was reported to be better achieved by ACBT than through progressive respiratory endurance in a single therapy session. The study found that ACBT significantly improved pulmonary function measures (FEV1, FEV1/FVC, and dyspnea).

Pulmonary rehabilitation, that includes PD, deep breathing exercises in addition to cough is an important aspect of the treatment and care of COPD since it improves patients' oxygen saturation, triflow volume, as well as pulmonary function testing (34).

Ultimately, our study found that both ACBT with PD and AD were successful in lowering airway resistance, with little to no apparent difference among the two.

REFERENCES

1. Marc B, Patrice F, Francis C, Gregory R. Effects of inspiratory muscle training in COPD patients: A systematic review and meta-analysis. Clin Respir J. 2018; 12 2178–2188..
2. Cess P van der Schans. Conventional chest physical therapy for obstructive lung disease. National Library of Medicine, 2007; 52(9):1198-206; discussion 1206-9.
3. Vanesa GB, Verónica VB, Elena BM, Maria del Carmen JE, Juan NC, Alicia CM, Márcio VF. Donadio and RodrigoTorres-Castro. Immediate Effects and Safety of High-Frequency Chest Wall Compression Compared to Airway Clearance Techniques in Non-Hospitalized Infants With Acute Viral Bronchiolitis. Respiratory Care March 2021, 66 (3)425-433.
4. Christine Mikelsons. The role of physiotherapy in the management of COPD. R Respiratory Medicine: COPD Update. 2008; 4: 2 – 7.
5. Jan M, Martin R, and Jakub R. Assessment of Respiratory System Resistance during High-Frequency Oscillatory Ventilation Based on In Vitro Experiment. Appl. Sci. 2021, 11(23), 11279; https://doi.org/10.3390/app112311279.
6. Celso R., Carvalho, Denise M. Paisani, ET AL.: Incentive spirometry in major surgeries: A systemic review. Rev. Bras. Fisioter. 2011; 15(5): 343-345.
7. Angshu, B., Kamaljeet, C., Gillian, A., Indranil C. Improving mucociliary clearance in chronic obstructive pulmonary disease. Respiratory Medicine 2009; 103: 496-502.
8. David A. Autogenic drainage-the German approach. In : Pryor JA (ed) Respiratory care. Churchill Livingstone, Edinburgh, 1991; pp 65-78.
9. Dab I. & Alexander F 1979. The mechanism of autogenic drainage sludied with flow volume curves. Monographs of Paediatrics, 10:50-53.
10. Vigei, Timens, W., and ten Hacken. Definition, epidemiology, and natural history of COPD. Eur. Respir. J. 2007; 30: 993–1013.
11. Chevaillier J. Autogenic drainage In: Physiotherapy in the treatment of cystic fibrosis, 2nd edn. International Physiotherapy Group for Cystic Fibrosis (IPG/CF), 1995; pp 9-12.
12. Bellone A.R., Lascoli, S., Raschi L., Guzzi and R. Adone: Chest physical therapy in patients with acute exacerbation of chronic bronchitis: Effectiveness of three.
13. Shintarou Kanda, Keisaku Fujimoto, Yoshimichi Komatsu, Masanori Yasuo, Masayuki Hanaoka and Keishi Kubo. Evaluation of Respiratory Impedance in Asthma and COPD by an Impulse Oscillation System. Inter Med. 2010; 49: 23-30.
14. Al-Mutairi SS, Sharma PN, Al-Alawi A, Al-Deen JS. Impulse oscillometry: an alternative modality to the conventional pulmonary function test to categorize obstructive pulmonary disorders. Clin Exp Med. 2007; 7(2):56-64.
15. Sultan DR. Satisfaction and clinical application value of impulse oscillometry in geriatric patients with chronic obstructive pulmonary disease in comparison with non-geriatric patients. Egypt J Chest Dis Tuberc [serial online] 2020 [cited 2022 Feb 1]; 69:64-71.
16. Timothée B, Thomas F, Julie M. Arnaud C, Sylvain MA, Laurent P. Impulse oscillometry and spirometry measurements relative to personal best values at the time of acute exacerbations of cystic fibrosis in adults . Clin Physiol Funct Imaging. 2021; 41:76–84.
17. Akane Haruna, Toru Oga, Shigeo Muro, Tadashi Ohara, Susumu Sato, Satoshi Marumo, Daisuke Kinose, Kunihiko Terada, Michiyoshi Nishioka, Emiko Ogawa, Yuma Hoshino, Toyohiro Hirai, Kazuo Chin, Michiaki Mishima. Relationship between peripheral airway function and patient-reported outcomes in COPD: a cross-sectional study BMC Pulmonary Medicine. 2010; 10(10):1-7.
18. Kris N, Francis T, Cindy T, Matt JE, Kim P.Early onset of airway derecruitment assessed using the forced oscillation technique in subjects with asthma. https:// doi.org/10.1152/japplphysiol.00534.2018,
19. Kong Q, Zhu J, Ho SCM & Song G. Tapping and listening: A new approach to bolt looseness monitoring. Smart Materials and Structures, 2018, 27(7), 07LT02.
20. Goñi-Viguria, R., Yoldi-Arzoz, E., Casajús-Sola, L., Aquerreta-Larraya, T., Fernández-Sangil, P., Guzmán-Unamuno, E., & Moyano-Berardo, B. M.. Respiratory physiotherapy in intensive care unit: Bibliographic review. Enfermería Intensiva (English ed.), 2018, 29(4), 168-181.
21. Goñi-Viguria, R., Yoldi-Arzoz, E., Casajús Sola, L., Aquerreta-Larraya, T., Fernández Sangil, P., Guzmán-Unamuno, E., & Moyano-Berardo, B.M. Respiratory physiotherapy in intensive care unit: Bibliographic review. Enfermería Intensiva (English ed.), 2018, 29(4), 168-181..
22. Fink, JB. Forced expiratory technique, directed cough, and autogenic drainage. Respiratory care, 2007, 52(9), 1210-1223.
23. Hristara-Papadopoulou, A., Tsanakas, J., Diomou, G., & Papadopoulou, O. . Current devices of respiratory physiotherapy. Hippokratia, 2008, 12(4), 211.
24. Alexandra, H. Physiotherapy in Respiratory Care. Third edition 2001, Nelson Thomes Ltd; 192-194.
25. Angshu, B., Kamaljeet, C., Gillian, A., Indranil C. Improving mucociliary clearance in chronic obstructive pulmonary disease. Respiratory Medicine 2009; 103: 496-502.
26. Chuter TAM. Weissman C, Starker PM. Gump FE. 1989. Effect of incentive spirometry on diaphragmatic function after surgery. Surgery 105:488-493.
27. Patterson, J.E., Bradley, J.M., Hewittm O., Bradbury, I. Airway clearance in bronchiectasis: a randomized crossover trial of active cycle of breathing techniques versus Acapella, 2005. National Library of Medicine, 72(3):239-42.

28. Patterson, J.E., Hewitt, O., Kent, L., Bradbury, I., Elborn, J.S., Bradley J.M. Acapella versus 'usual airway clearance' during acute exacerbation in bronchiectasis: a randomized crossover trial. Randomized Controlled Trial. Chron Respir Dis, 2007. 4(2):67-74.
29. Mikelsons C. The role of physiotherapy in the management of COPD. 2008, Volume 4, Issue 1, February 2008, Pages 2-7.
30. Wange, P., Jiandani, M., & Mehta, A. Incentive spirometry versus active cycle of breathing technique: Effect on chest expansion and flow rates in post abdominal surgery patients. Int J Res Med Sci, 2016, 4(11), 4762-6.
31. Melam, G. R., Zakaria, A. R., Buragadda, S., Sharma, D., & Alghamdi, M.A. Comparison of Autogenic Drainage & Active Cycle Breathing Techniques on FEV1, FVC & PERF in Chronic Obstructive Pulmonary Disease. World Applied Sciences Journal, 2012, 20(6), 818-822.
32. Savci, Sema, Deniz Inal Ince, and Hülya Arikan. "A comparison of autogenic drainage and the active cycle of breathing techniques in patients with chronic obstructive pulmonary diseases." Journal of Cardiopulmonary Rehabilitation and Prevention 20.1 2000,: 37-43.
33. Mohammed, Bashar S., et al. "Properties of nano silica modified rubbercrete." Journal of cleaner production 2016, 119: 66-75.
34. Selma A., Kıvan Ç. Effect of Postural Drainage and Deep Breathing-Cough Exercises on Oxygen Saturation, Triflo Volume and Pulmonary Function Testin Patients with COPD. Journal Of Clinical And Experimental Investigations, 2021, Vol. 12 , No. 4 .