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Efficacy of the flutter therapy in airway clearance

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ABSTRACT

Flutter therapy is a well-known positive expiratory pressure device used for airway clearance among individuals with respiratory disorders. This review aims to determine the impact of flutter therapy in pulmonary conditions and also to determine its extent of effectiveness in improving various outcomes including mobilization of sputum and pulmonary functions and the methods of using flutter therapy to add on its effectiveness in treating respiratory disorders. A literature search was performed in a database like PEDRO, PUBMED, Google scholar, research gate, science direct and EBSCO. From the selected databases reviews about the use of flutter were determined.

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INTRODUCTION

Respiratory diseases are the chronic diseases of respiratory tract which is of obstructive and restrictive lung disorders. Among which the most common diseases are Bronchial asthma and chronic obstructive pulmonary diseases that is chronic bronchitis and emphysema (Sahbanathul Missriya M.A *et al.,* 2017). A decreased rate of airflow characterises obstructive disorders during expiration as a result of increased airway resistance and abnormal inflammatory response in the lungs (Mohammed Altaf *et al.,* 2016). Restrictive lung diseases are conditions in which the inspiratory capacity of the lungs is restricted to less than normal. An overlap between obstructive and restrictive conditions does exist most commonly. Moreover, the global prevalence of these diseases are increasing the burden and the disease challenges the public health in both industrialized and developing countries. Chronic obstructive pulmonary condition is a disabling respiratory disorder with airflow obstruction that is not fully reversible that is characterized by chronic and progressive breathlessness, cough and sputum associated with frequent exacerbations of COPD and clinically result in negative effects on pulmonary functions, quality of life and mortality (Osadnik, Christian R *et al.,* 2013).

Respiratory dysfunction is a common problem among critically ill patients as their primary problem is secretion retention which affects gas exchange membrane and ventilator pump impairs the global or regional ventilation, decreases lung compliance and increases airway resistance that contributes to increased work of breathing and respiratory dysfunction (R Gooselink *et al.,* 2011). The main task of the mucociliary system in the respiratory tract is to eliminate the inhaled foreign particles by the propulsion of mucus, this effect of propulsion of mucus depends on the arrangement of cilia and ciliary beat frequency as its metachronism regulates the intracellular and intercellular mechanisms to enhance the ciliary activity to clear mucus as ciliary disorders like lack of ciliary epithelium and ciliary disorientation are associated

with low ciliary activity and are common among respiratory diseases (Yi, W.J *et al.,* 2003). Secretion retention increases the airway resistance and leads to hypoventilation, respiratory dysfunction, hypoxia, carbon dioxide retention also further complicates to sputum scabs clogging the airway which is life-threatening. Hence, secretion clearance is the most important procedure to maintain a clear respiratory tract and to prevent infections and promote alveolar ventilation. The study demonstrates that timely mucus clearance prevents ventilated associated pneumonia among mechanically ventilated patients (Shi Yan *et al.,* 2015). Also, airway clearance is the first line of management for all respiratory disorders to prevent further complications and to promote recovery.

Flutter is a device used for airway clearance which was introduced in early nineties as an adjunct to manual chest physiotherapy techniques (U.H. Cegla, 2000) which has been gold standard methods of treatment for drainage of secretions for various respiratory conditions such as bronchiectasis, COPD, cystic fibrosis, postoperative complications (Marina Eleni Kloni *et al.,* 2014)

There is an increased mortality rate in Respiratory conditions which are generally caused by destruction of airway walls (Fernando S.Guimaraes *et al.,* 2011) and accumulation of secretion are caused by imbalance between the mucus secretion and mucus clearance system (John H. Marks., 2007) Later on this causes severe problem such as retention of secretion, repeated pulmonary infection, increased hospitalization and in many cases it may lead to mortality (John H. Marks., 2007). For these reasons bronchial hygiene technique is employed, flutter is one of the technique which works on the mechanism of Positive Expiratory Pressure (PEP) which helps in mobilizing the secretions (Luiz Antonio Alves *et al.,* 2008) Presence of excessive cough indicates that there is an increase in respiratory illness and infection, imbalance in this mechanism leads to increased work of breathing (John H. Marks., 2007).

Flutter is a hand-held device which is made up of hardened plastic material. It consists of mouthpiece at one end and stainless steel ball resting on the cone at the other end (Hristara Papadopoulou A *et al.,* 2008) during exhalation the positive expiratory pressure created from the airway is transmitted to the flutter which makes the steel ball inside the flutter to oscillate within the cone and produce a vibration frequency of about 15Hz (Adrian H Kendrick., 2007). The oscillatory effect produced in the central airway loosens the secretion and the patient easily removes the mobilized secretions by coughing. Flutter can be adjusted in different angles and modify flow accordingly, that contributes to the removal of secretion (Adrian H Kendrick., 2007). It is a small and easily manageable pocket device. Compared to other airway clearance technique flutter is more effective, less time consuming and it does not require any assistance during the treatment (Monika Fagevik Olsen *et al.,* 2009)

After the treatment with flutter, there is a reduction in FRC, RV, TLC which in turn reduces the pulmonary hyperinflation as, during expiration, flutter stabilizes the airway with PEP mechanism by improving collateral ventilation to avoid lung collapse and helps in removal of secretion (Fernando S.Guimaraes *et al.,* 2011). The main aim of the device is to produce the oscillatory effect and loosen the secretion by changing their viscoelasticity property (C S Thompson *et al.,* 2002). There is an increased mortality rate in the patient with respiratory disease due to the accumulation of secretions which obstructs the airways. Compared to other airway clearance technique flutter is more effective and less time-consuming. It does not require any assistance and dependency (Adrian H Kendrick *et al.,* 2007). We proposed this study to collect the various literature based on the flutter device to specify the effective use of flutter therapy pertaining to the condition and its effectiveness in improving the outcome measures. Hence this literature study is beneficial to determine the extent of uses of flutter in improving various outcomes and to determine the techniques used to improve the effectiveness of flutter therapy.

MATERIALS AND METHODS

Search Strategy

A comprehensive Literature search was conducted from databases of Medline, EBSCO, DOAJ, Science Direct, PEDRO, Google scholar, PUBMED. We identified randomized controlled trials and case studies from 2000 to 2015. Search terms were Flutter therapy, Airway clearance Device, Effect of Flutter, Respiratory disorder, the effect of flutter on pulmonary function. As an additional source of search criteria reference list, conference abstracts and bibliography of pertinent articles were identified in the search and potentially eligible trials were included

Study selection

Two investigators independently screened the titles and abstracts of all the studies that had been retrieved from the database. Standard screening checklist was used for eligibility criteria. Studies which did not meet the screening criteria were excluded.

Data Extraction

Three investigators independently reviewed the extracted data. Reviewers discussed the inclusion

of studies and characteristics that have to be included and the difference in opinion was clarified and resolved. Moreover, recorded the following characteristics First author, Title and Year, Sample size and samples, study design, Treatment is given, determined outcome measures, results and conclusion.

Outcome measures

Categories of outcome measures examined for this review are based on the outcome measures of research articles involved in this review study. Subjective outcomes were based on History and Clinical Examination determined the Frequency of a daytime and nocturnal cough, length of Hospital Stay. Vitals like Respiratory rate and Heart Rate were determined. Dyspnea scores and quality of life assessed using variables like Chronic Respiratory Disease Questionnaire, Modified Borg scale, SCM, Quality of Well Being Scale. Objective Outcomes involving pulmonary function were determined with Spirometry for FEV1, FVC, PEFR, FEV1/FVC. Sputum analysis determined quantity of sputum, Arterial blood gas analysis PaO2, PaCO2, Exercise capacity measured with 6 Minute Walk Test, other determined variables were Contact Angle Measurement, Stimulated Cough Machine Transport, Oscillation Frequency (dR/dF), Oscillometry Impedance of 5Hz (R5), Reactance at 5Hz (X5), Resonant Frequency (f_0), Integral of Reactance between 5Hz and Resonant Frequency (AX), Transcutaneously Measured Oxygen, Transcutaneously Measured Single Breath Inert Gas Test, Distribution of ventilation, Gas Mixing, MAP, Pet CO_2, Cst, rs, Rhinitis.

RESULTS

Characteristics for quality assessment

Those studies conducted between the years 2000 to 2015 were included. The population were COPD, Bronchiectasis, Cystic fibrosis, old age people and mechanically ventilated patient, chronic bronchitis. There was a total sample size of 406 among 18 studies of which 4 studies involved 53 Bronchiectasis patients, 5 COPD studies with 148 samples, 40 samples among 2 studies of chronic bronchitis, 85 cystic fibrosis patients were observed in 5 studies. Also, one study was performed among elderly individuals with 60 samples and 1 study included 20 mechanical ventilated patients.

The effectiveness of flutter therapy on expiratory pressures was determined in which the flutter device is attached with pneumotachograph and a ventilator, and measured the different flows and expiratory pressure generated by ventilator using a pressure transducer. There was a strong significant correlation between flow and expiratory pressure at each level of incline from angles +40 degree to – 40 degree. The correlation was also observed between expiratory pressure and oscillation frequency. Moreover, the study concluded that positive incline and large airflow increase expiratory pressure (Dina Brooks *et al.,* 2002).

Flutter device was compared with standard chest physiotherapy in cystic fibrosis patients and determined that flutter therapy is safe, efficacious and cost-effective. (Douglas 1998). Sputum rheological changes were observed in cystic fibrosis patients using two techniques that is flutter therapy compared with autogenic drainage, in vitro experimenter performed in which airflow oscillations were generated by passing humidified air over cystic fibrosis sputum lining an acrylic tube connected at its outlet to a flutter device, following which a filancemeter measured sputum elasticity and it was found that sputum elastic properties were affected significantly by application of oscillations generated by flutter device for 15 to 30 minutes, the mean airflow velocity was approximately 1.5L/s, and the cross-sectional area of the tube was 2.2cm^2 and the median frequency generated in flutter was 19 Hz. Hence these findings suggest that applied oscillations are capable of decreasing mucus viscoelasticity within the airways at frequencies and amplitudes achievable with flutter device (Ernst M. App *et al.,* 1998)

Even though the utilization of airway clearance procedures (Pedro H.S *et al.,* 2012) is viewed as an imperative part in the treatment of a few obstructive pulmonary diseases, there is no logical proof supporting the utilization of Flutter Valve in the administration of patients with bronchiectasis. Eight patients were assessed in a randomized, blinded, traverse trial. Impedance at 5 Hz (R5), resistance as a component of oscillation frequency (dR/dF), reactance at 5 Hz (X5), resounding recurrence (f0) and necessary of reactance between 5 Hz and resonant frequency (AX) were recorded. Shudder Valve TM expands sputum evacuation amid treatment and decreases aggregate and fringe airway resistance in hyper-secretive patients with bronchiectasis. Drive oscillometry is easy to use the device to assess the impacts of airway clearance systems on respiratory mechanics. Measurement: Reduction in R_5, AX and dR/dF was observed following treatment with flutter valve compared to sham flutter intervention. Patients showed a high volume of sputum production in Flutter valve and reduced peripheral airway resistance.

C.S.Thompsonet.al., (2002) conducted a randomized crossover study among 17 non-cystic bronchiectases with ACBT and Flutter and found there was no significant difference between the ACBT and Flutter. Median (IQR) daily sputum weight. 26.6g (15.0-45.2) for ACBT. 23.4g (16.8-36.2) for flutter.

PEFR-After morning session: 2.50 (-6.95 to 1.52). After evening session: 2.72 (-0.08 to 0.34). Borg scale - There was no difference between the two groups. The improvement was observed in FEV1 with flutter compared to ACBT. The chronic respiratory questionnaire, p-value (>0.99). The study recommended flutter to the patients with bronchiectasis. If preferred by patients then they are recommended to use daily.

Qi-Xing Wang et al., (2010) Randomized controlled trial with 60 elderly individuals (>85 years). There was no significant difference in PEF, FEV1, FVC and FEV1/FVC between the 2 groups at baseline. However, in flutter group FVC, VC improved in the elderly patient. The mean ± SD baseline values were: PEF 103.2±43.0 L/min, FEV1 0.98±0.43L and FVC 1.76±0.68L. Compared to baseline, on day 28 there was no significant difference in PEF, FEV1, or FEV1/FVC, in either group. The mean ±SD difference in FVC between baseline and day 28 was 0.33±0.30 L in the intervention group, and 0.20 ±0.14 L in the control group (P< 0.03). Flutter device helped to clear some components of pulmonary function testing. Further study is recommended to improve pulmonary functions among the elderly via respiratory exercises.

Fernando S. Guimaraes et al., (2011) conducted a randomised crossover study with 10 bronchiectasis individuals compared ELTGOL and flutter, both showed a reduction in RV, FRC, TLC, compared to control group. Reduction in IC/TLC was observed in flutter group. The dry weight of secretion was higher in ELTGOL compared to flutter. ELTGOL increased secretion removal. Whereas flutter and ELTGOL reduced lung hyperinflation.

Fernando Silva Guimaraes et al., (2014) compared the flutter and ELTGOL between 8 adults with cystic fibrosis tested the effects on sputum dry weight, spirometry and plethysmography ELTGOL cleared 0.34g of secretion when compared to flutter. Flutter therapy reduced TLC (p 0.024) FRC (p 0.035) RV (p 0.027) RV/TLC (p 0.024) Raw (p 0.001) (SGV_a: p 0.001) ELTGOL reduced raw (p<0.001) SGV_a (p <0.001) and SPO_2 (P 0.034). Both the techniques equivalent in reducing pulmonary hyperinflation and air trapping. Whereas ELTGOL reduced secretions and improved airway resistance.

M.Ellen Newbold et al., (2005) compared the flutter device with positive expiratory pressure mask among 42 cystic fibrosis individuals to determine its effects on PFT (FEV1, FVC, $FEF_{25-75\%}$). Quality of well-being scale (QWB) Chronic respiratory disease questionnaire (CRQ). No significant difference between the two groups in the mean slope or annual rate of change in (FEV1, FVC, $FEF_{25-75\%}$). Quality of well-being scale: Flutter group (-0.001±0.01) PEP group (-0.006 [±0.02]) Chronic respiratory disease questionnaire: Flutter group (0.1[±1.0]) PEP group (0.1[±0.9]). There was a significant difference observed between flutter and PEP group involving children, and adolescents versus adults. Further evaluation is recommended in physiological effects of flutter and PEP mask in airway clearance.

Norman wolkole et al., (2002) determined the effects of flutter with sham flutter therapy in 23 stable COPD patients. There is a significant improvement after the use of flutter. There is a mean improvement after the bronchodilator 186±110ml in the group of flutter and in sham MCD group it was 130± 120ml. Spirometric variables: There is an improvement in FEV1, FVC in flutter group compared to the sham MCD group. 6 minute walk distance was improved in Flutter MCD: 174±92 compared to sham MCD:162± 86 Borg scale dyspnoea scores in MCD group improved from 1.6 in the pre to 4.0 in the post sham MCD dyspnoea score in pre was 1.9 to 4.4 in the post. COPD patients exhibited a significant response with bronchodilators like ipratropium and salbutamol and MCD enhanced the functional improvement.

Joana Tambisco et al., (2011) determined the influence of flutter VRP1 components on mucus transport of 18 patients with bronchiectasis in a crossover study between flutter with high-frequency oscillations compared with positive expiratory pressure device study the Relative transport velocity displacement simulated cough machine transport (SCM) Contact angle measurement (CAM). The average positive expiratory pressure was determined patients achieve the pressure of 15.7 cm H_2O with a range of 4 – 32cm H_2O Relative transport velocity showed no significant difference concern to treatment weeks or type of treatment duration. The flutter treatment shows increased displacement of values in the fourth week for SCM and CAM was reduced in the first week when compared to 4^{th} week p<0.05. In comparison with treatment weeks, no difference was observed in contact angle values. Flutter device proved to be effective when performed for four weeks as it related to high-frequency oscillation component it effectively transported respiratory secretions.

Shabnam Jahan et al., (2015)., conducted a randomized crossover study between flutter therapy and autogenic drainage on peak expiratory flow rate, oxygen saturation, respiratory rate and pulse rate in 30 patients with COPD patients. There is no significant difference between group A and group B of peak expiratory flow rate. Whereas within the group analysis shows mean values have increased in post-test. Arterial Saturation (SPO2): there is no significant difference found between 2 groups, but

within the group, the analysis shows that mean values are higher in comparison with pre and post-test P value=0.001) Respiratory rate: No significant difference between two groups. Whereas within group analysis statistically highly significant results. Pulse rate: No significant difference between the groups as P>0.05 within groups shows high statistical significant results for both Group A and Group B as p=0.0001. Flutter and Autogenic drainage were proved to be equally effective in improving the PEFR, RR, HR and SPO_2 among patients with COPD. Thereby treatment of choice can be decided according to patient and physiotherapist convenience.

Nesreen G et al., (2011) 20 patients with COPD treated with flutter therapy an oscillatory positive expiratory pressure device improved exercise capacity and PEFR in COPD patients. When compared between pre-test and post-test analysis the mean values PEFR increased significantly with p-value 0.0001. Six Minute Walk distance results showed that there is a significant increase in posttest compared pretest and it also increased arterial oxygen saturation level (SPO2) with p-value highly significant with p 0.0001. Flutter an oscillatory positive expiratory pressure device improved exercise capacity and PEFR in COPD patients.

Anna-Lena B Lagerkvist et al., (2006) Immediate changes in blood-gas tensions during chest physiotherapy with positive expiratory pressure and oscillating positive expiratory pressure (PEP) in 15 patients with cystic fibrosis. Randomized crossover study PEP compared with Oscillating PEP. There was no significant difference in spirometry variables. Whereas, transcutaneously measured Oxygen tension and Carbon dioxide tension shows the result at steady state no changes in p_{tO2} or P_{tCO2} in the PEP group. In oscillating PEP P_{tO2} increased and P_{tCO2} decreased. The results obtained immediately after oscillating PEP showed a higher P_{tO2} and a lower P_{tCO2} than with PEP. Oscillatory PEP causes higher changes compared to PEP whereas both PEP and Oscillatory PEP produced transitory effects on blood gases among Cystic fibrosis patients

Richa et.al., (2010) done a randomized crossover study between flutter therapy, active cycle of breathing technique and breathing exercises among 45 males with COPD in which following treatment peak expiratory flow rate (PEFR) shows a significant increase in both Group A (p<0.001) and Group B (p<0.001). Whereas in Group C it was not significant. Respiratory Rate (RR) showed no significant difference between Group A and Group B as p value>0.05. When Group Acompared with Group C, it shows a significant difference on 3rd day evening session after treatment (p=0.001). Group B when compared with Group C shows no significant difference in RR (p>0.05) Arterial Oxygen Saturation (SpO2): There was no statistical difference in Group A and Group B (p>0.05). When Group A compared with Group C Within-group analysis showed a significant improvement in SpO2 in Group A (p<0.001). Observations on hospital stay (HS) showed that the patient using flutter had a less hospital stay compared with other groups. When compared to Group C both Group A and Group B demonstrates a significant difference. Both flutter and ACBT are equally effective in improving pulmonary function and saturation of oxygen and reduced hospital stay when compared to breathing exercises. Hence these techniques can be utilised according to the patient and physiotherapist preference.

Sandra Ribeiro Pires et al., (2013) 14 cystic fibrosis patients treated with EPAP and flutter therapy determined the pulmonary function parameters There be a slight increase in mean values of TLC, FRC, RV, RV/TLC with flutter compared to EPAP. However, the increase was not statistically significant as Pvalue>0.05 There was no difference in SPO_2 values following both the interventions. Neither device showed significant changes in pulmonary static volumes and functions among adolescents and adults with cystic fibrosis.

Joan C Darbee et al., (2004) Compared the physiologic evidence of low PEP Breathing, high PEP breathing and no PEP breathing in 6 cystic fibrosis patients determined the Single breath inert gas test, Distribution of ventilation, Sputum dry weight, Gas mixing, lung function test. After the treatment of 45 minutes, there was an improvement in all the three groups, distribution of ventilation was assessed with phase III alveolar slope of single inert gas increased 35% after intervention in low PEP. In high PEP increase was up to 39% after intervention and in no PEP it is 2% after intervention. Gas mixing improved to 23 % in high PEP when low PEP raised only to 15% and 5% in no PEP group was observed. Slow vital capacity increased to 13% in high PEP, followed by 9% in low PEP and 1% in no PEP. Residual volume is decreased in all three groups with more decrease in high PEP followed by low and no PEP. FEV_1 increased to 9% in high PEP, 7% in low PEP and 1% in no PEP. $FEF_{25\%-75\%}$ increased to 22% in high PEP, 29% in low PEP and 7% in no PEP group. SPO_2 levels increased with low PEP breathing and high PEP breathing and no changes seen in no PEP. Sputum dry weight increased in all groups. Throughout the treatment period. Largest sputum expectoration was compared in 3 levels during, immediately after and 45 minutes after intervention. The study concluded that both the low PEP and high

PEP improves gas mixing associated with an increase in lung function, SPO_2 and sputum expectoration among the patients with cystic fibrosis.

Ahmed Y. Gad et al., (2013) compared the conventional treatment with flutter therapy in 30 COPD patients Both the groups showed improvement following the treatment in dyspnoea, cough and a 6 minute walking distance. After the treatment of group II, there was a decrease in the duration of hospital stay and significant difference between Pre and post values of partial pressure of PaO_2, $PaCO_2$ and HCO_3 and SPO_2. There was a significant decrease in the use of short-acting B2 agonist in Group 2 patients. Pulmonary function parameters improved in mean values within the groups and between the groups. However, the difference was not statistically significant. There was no adverse effect reported due to Flutter, It is a portable device, easy to use and does not require any assistance during the treatment.

Andrea Bellone et al., (2000) compared the effectiveness of three methods postural drainage, flutter device and ELTGOL in 10 patients with chronic bronchitis. Sputum production increased significantly after thirty minutes in all the groups, with more increase in Flutter and ELTGOL than with Postural Drainage. There was no significant difference in PFT and oxygen saturation. All three treatments are effective in removing the secretion without any undesirable change in oxygen saturation. However, FLUTTER and ELTGOL are more effective in removing the secretion than Postural Drainage (PD) among the patients with chronic bronchitis.

Luciano M Chicayban et al., (2011) performed a randomized crossover trial the effects of flutter valve improve respiratory mechanics and sputum production in 20 mechanically ventilated patients Secretion production was higher in flutter intervention. There was no significant difference seen in Respiratory mechanics (Cst, rs Rrs, Rinit, rs, PF, flow 75%) at baseline between flutter and control intervention. There is an increase in Cst, rs, PF and flow of 75% was observed effective in flutter intervention. No difference was seen in Rrs, Rinit, rs between control and flutter intervention. PaO_2/FiO_2 improved in the flutter and reduced in the control group. MAP increased in flutter intervention in the second series. $PetCO_2$ decreased at 12 minutes of both first and second series in control intervention. SpO_2 increased in flutter intervention. Flutter valve proved useful in mechanically ventilated patients with respiratory infections. Flutter promoted airway clearance by removing secretions, increased static compliance of the respiratory system and arterial oxygenation.

Smibi Skaria *et al.,* (2008) compared the effects of Flutter and Autogenic Drainage in 30 patients with chronic bronchitis in PEFR, oxygen saturation and dyspnea t' value shows that PEP technique has a significant effect than the AD in improving bronchial hygiene technique. Both the group shows a significant change in the oxygen saturation. Borg scale shows improvement in both the groups. PEP technique has a more significant effect on improving bronchial hygiene than the AD. Thereby this study helps to promote bronchial hygiene in patients with chronic bronchitis.

DISCUSSION

The Flutter device was created in Switzerland and consolidates positive expiratory pressure therapy with high–frequency motions inside the airway. It is a controlled vibration system which produces positive expiratory pressure and cyclic swaying of the airways amid termination. The Flutter device is a compact device intended to help clear mucus in patients with lung issue (Denehy., 2006) The guideline behind this device is that exhalation into the Flutter valve causes a steel ball–bearing to sway at a high recurrence, bringing about the vibration of the airways and discontinuous positive expiratory pressure, to encourage mucus expectoration. Lapse ought to be moderate through the Flutter valve, causing motions of the steel ball inside the cone of the Flutter. Patients apply rehashed exhalations through the Flutter valve (Moravec, Christine S., 2011)

The result of this trial is very difficult to make in a single sentence whether the flutter therapy is effective or not. After checking for selection criteria, eighteen studies were included in this review. This review is clinically and scientifically applicable for both clinicians and researchers involving patients with bronchiectasis, COPD, cystic fibrosis, retention of secretions, chronic bronchitis, elderly individuals and mechanically ventilated patients. This review included studies of all design except pilot, review articles and observational study. Only studies in English were reviewed and this might have missed some other important studies. The increased variability regarding comparison interventions, follow up and outcome measures also made it very difficult to compare results across studies and conclusions. One trial showed similar effects of flutter and ELTGOL (Fernando S.Guimaraes., 2011) While three trials presented a better effect in flutter technique (Joana Tambascio *et al.,* 2011, Joan C Darbee *et al.,* 2004, Luciano M Chicayban *et al.,* 2011)

Various studies show a positive effect on different outcome measures. One trial shows an increased sputum amount, decreased a cough and mucus production (John H. Marks., 2007) improved six-

minute walking distance (Norman Wolkove *et al.,* 2002 and Nesreen G.Elnahas *et al.,* 2011) and increase in exercise capacity (Nesreen G.Elnahas *et al.,* 2011). Luiz Antonio Alves *et al.,* 2008, demonstrated different ranges of PEP device and its administration techniques to be used in clinical practice and it proved that pressure produced during expiration is dependent on different flows and angles of flutter. The definition of COPD varied in included trials. Most of the trials have focused on pulmonary function test and amount of sputum (Guimaraes *et al.,* 2014, M. Ellen Newbold *et al.,* 2005, Norman Wolkove *et al.,* 2002, Sandra Ribeiro Pires *et al.,* 2013, Joan C Darbee *et al.,* 2004, Ahmed Y. Gad *et al.,* 2013, Andrea Bellone *et al.,* 2000) But neither device showed significant changes in pulmonary static volumes and functions among adolescents and adults with cystic fibrosis (Sandra Ribeiro Pires *et al.,* 2013). Only one trial related to the length of the hospital stay which is important variables in the health economy (Richa., 2010) Most of the studies included in this review were randomized crossover study.

Flutter is used in various condition of which five trials are supporting COPD (Norman Wolkove *et al.,* 2002, Shabnam Jahan *et al.,* 2015, Nesreen G. Elnahas *et al.,* 2011, Richa., 2010, Ahmed Y. Gad., 2013) out of which one trial shows a significant improvement in the spirometric variables and other trials show improvement in exercise capacity (Nesreen G.Elnahas *et al.,* 2011). Four trials supporting bronchiectasis (Fernando S.Guimaraes *et al.,* 2011, C S Thompson *et al.,* 2002, Pedro H.S. Figueiredo *et al.,* 2012, Joana Tambasico *et al.,* 2011) five researches proved effective in cystic fibrosis (Fernando Silva Guimaraes *et al.,* 2014, M. Ellen Newbold., 2005, Anna-Lena B Lagerkvist *et al.,* 2006, Sandra Ribeiro Pires *et al.,* 2013, Joan C Darbee *et al.,* 2004) two studies supporting chronic bronchitis, one randomized study demonstrated its effects in improving pulmonary function in elderly individuals (Qi-xing Wang., 2010). A crossover study with Flutter promoted airway clearance and increased static compliance of the respiratory system in mechanically ventilated patients (Luciano M Chicayban., 2011) Flutter therapy proved to be equally effective when combined with Autogenic drainage, Active cycle of breathing and ELTGOL (Fernando S.Guimaraes *et al.,* 2011, C S Thompson *et al.,* 2002, Fernando Silva Guimaraes *et al.,* 2014, Shabnam Jahan *et al.,* 2015, Richa *et al.,* 2010, Sandra Ribeiro Pires *et al.,* 2013, Joan C Darbee *et al.,* 2004). There are no adverse effects reported with the use of Flutter. Flutter is a portable device, easy to use and it does not require any assistance during the treatment. Hence treatment of choice can be decided according to the patient and therapist preference. When combined with techniques like ACBT, AD, ELTGOL flutter is equally effective in improving conditions like Bronchiectasis and COPD. Further good quality clinical trials are necessary to conclude the effectiveness of flutter therapy.

CONCLUSION

The reviewed evidence show that stands alone flutter therapy is effective in a certain respiratory condition like COPD, Cystic Fibrosis, Elderly Individuals, Chronic bronchitis and mechanically ventilated patients. Implementation and evaluation in the clinical environment would strengthen the evidence base.

CONFLICT OF INTEREST: The authors confirm that this study has no conflict of interest.

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