International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 9 Issue 1 Series. II || Jan.2020 || PP 01-10

Efficiency Of New Visual Biofeed Back Device – Synchronized Breathing Trainer – For Training Breathing Control

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Abstract: Objectives: *Designing a new device to evaluate the efficacy of the device in lung functions and physical performance for patients with respiratory problems and to construct reliability for the device.* ***Design:****Experimental study ,cross-sectional design with constructional validity.* ***Setting:*** *Dr. D.Y.Patil Vidyapeeth Pimpri, Pune.* ***Participants:*** *Patients with obstructive and restrictive respiratory conditions.* ***Intervention:*** *Patients were selected through purposive sampling. Pre and Post assessments were taken for each of the 30 subjects. Respiratory rate, Inspiratory:Expiratory ratio , chest expansion(upper and lower), 6 minute walk test(laps and distance covered) and ERV was assessed pre and post training with the new breathing control device. Breathing retraining was given for each patient for 15-20 minutes.* ***Results:*** *Respiratory rate, Inspiratory : Expiratory ratio, chest expansion and 6MWTshowed significant improvements after breathing with the new breathing control device. ERV did'nt showed any significant improvement.****Conclusions:*** *Breathing retraining with the new breathing control device is effective in patients with respiratory disorders. The device showed functional improvements amongst the patients but there was no physiological improvements amongst the patients.*

KEYWORDS: *Breathing control, COPD, I:E ratio, lung functions, 6MWT, Chest expansion.*

Date of Submission: 20-01-2020 Date of Acceptance: 05-02-2020

I. Introduction

The respiratory systems major functions are to provide an adequate oxygen supply to meetthe energy production requirements of the body and maintain a suitable acid-base status byremoving carbon dioxide from the body. This is accomplished by moving varying volumes ofair into and out of the lungs. Ventilation , the process of air movement into the lungs , is acarefully controlled modality with a wide range of response that enables the markers of gasexchange adequacy(PaO2, PaCO2, and pH) to be kept within a relatively small physiologicrange. The act of normal breathing has a relatively constant rate and inspiratory volume thattogether constitute normal respiratory rhythm. Ventilation at rest in most individuals requiresonly the inspiratory muscles. Expiration is usually passive and is secondary to the respiratorysystem returning to its resting state. The accessory muscles of inspiration(sternocleidomastoid and scalenes) and expiration(abdominal) are not normally used in theresting state. (1) The primary organs of the respiratory system are lungs, which are a pair oflarge, spongy organs optimized for gas exchange between our blood and the air. The airpasses through either the mouth or the nose, travels throughthe nasopharynx, oropharynx, larynx,and the trachea (windpipe), which then divides into twomain bronchi ;these branch to the left and right lungs where they progressively subdivide intoa system of bronchi and bronchioles until the alveoli are reached. These many alveoli arewhere the gas exchange of carbon dioxide and oxygen takes place.

The respiratory system is made up of organs and tissues that help you breathe. The main partsof this system are the airways, the lungs and linked blood vessels, and the muscles that enablebreathing. (2)

Breathing In (Inhalation)- When one breathes in, or inhales, the diaphragm contracts(tightens) and moves downward. This increases the space in our chest cavity, into which ourlungs expand. The intercostal muscles between the ribs also help enlarge the chest cavity.They contract to pull the rib cage both upward and outward when one inhales.

Breathing Out (Exhalation)- When one breathes out, or exhales, the diaphragm relaxes andmoves upward into the chest cavity. The intercostal muscles between the ribs also relax toreduce the space in the chest cavity. As the space in the chest cavity gets smaller, air rich incarbon dioxide is forced out of the lungs and windpipe, and then out of the nose or mouth.Breathing out requires no effort from the body unless having any lung disease or being doingany physical activity. When physically active, the abdominal muscles contract and push thediaphragm against the lungs even more than usual. This rapidly pushes air out of the lungs. (3)

1.1 Breathing pattern and its importance

Breathing is a central aspect of the whole being and is one of the most vital functions. Adisordered breathing pattern can be the first sign that all is not well, whether it be amechanical, physiological or psychological dysfunction. It is essential, therefore, thatbreathing is considered in all physiotherapy assessments (3) .) The respiratory rate and tidalvolume vary in response to metabolic demand and increase with physical activity or indisease states such as infection. Importantly, the magnitude of the metabolic demand isreflected in the respiratory rate, and patients with an elevated respiratory rate often have amore serious illness. Severity of disease classification systems including the AcutePhysiology and Chronic Health Evaluation (APACHE), CURB-65, and pneumonia severityindex (PSI) all incorporate the respiratory rate to identify the most critically ill patients. (4)Deep and slow inspiration is considered to be a therapeutic breathing exercise. Deepinspirations imitating a yawn or a sigh mechanism promote an increase intranspulmonary pressure and, when associated with a post-inspiratory pause,increase the functional residual capacity. This leads to a greater alveolar stability (5) .

Normal breathing pattern:- A costodiaphragmatic breathing type is observed when theabdominal and lateral costal expansion is predominant over the superior thoracic expansionduring inspiration at rest. This is considered the optimal or normal breathing type because itallows maximum lung expansion and, therefore, maximum lung capacity and gas exchange.

Abnormal breathing pattern:- The upper-costal breathing type takes place when superiorthoracic expansion exceeds the abdominal and lateral costal expansion during inspiration atrest. This breathing type produces a smaller expansion of the rib cage and thus reduced lungcapacity and gas exchange. Hence, excessive use of accessory muscles may be required tocompensate for insufficient gas exchange (6) .The average breathing type for men and women is abdominal during quiet breathing. Duringdeep breathing the abdominal movements are significantly less amongst the women than themen. The average respiratory rate is 14 during quiet and 7.4 during deep breathing for bothsexes. The rhythm(inspiration/expiration ratio) was 1:1.21 for men and 1:1.14 for womenduring quiet breathing and 1:1.23 for men and 1:1.40 for women during deep breathing (7) .

Benefits of correct breathing pattern upon respiratory system

It dramatically aids in relief of many long term respiratory difficulties such as asthma,bronchitis, COPD. Reduces chest pains due to tight muscles thus the tension causing anxietyof "heart attack potential" is reduced. Thus opens up the chest to make breathing easier andfuller which facilitates strengthening of the life force, emotional stability and mental clarity tofeel more energetic and maintains body balance which supports ease of breathing includingproper CO2 elimination.

1.2. Breathing control and its importance

Breathing techniques can be divided into normal breathing , known as “breathing control” ,where the pattern of breathing is maximally efficient for the individual with minimal effortexpended, and breathing exercises, where either inspiration is emphasized(as in thoracicexpansion exercises and inspiratory muscle training) or expiration is emphasized(as in huffof the forced expiration technique). Breathing control is normal tidal breathing using thelower chest and encouraging relaxation of the upper chest and shoulders. This technique isknown as diaphragmatic breathing. Breathing control may also be used to improve exercisecapacity in breathless patients when walking up slopes, hills and stairs. It can also be used tocontrol a bout or paroxysm of coughing (8) . Controlled breathing is included in therehabilitation program of patients with chronic obstructive pulmonary disease (COPD). Inpatients with COPD, controlled breathing works to relieve dyspnea by (1) reducing dynamichyperinflation of the rib cage and improving gas exchange, (2) increasing strength andendurance of the respiratory muscles, and (3) optimizing the pattern of thoracoabdominalmotion. Evidence of the effectiveness of controlled breathing on dyspnea is given for pursed-lips breathing, forward leaning position, and inspiratory muscle training. The aims of theseexercises vary considerably and include improvement of (regional) ventilation and gasexchange, amelioration of such debilitating effects on the ventilatory pump as dynamichyperinflation, improvement of respiratory muscle function, decrease in dyspnea, andimprovement of exercise tolerance and quality of life (9) . Thus controlled breathing improvesoutcome of pulmonary rehabilitation. Various breathing control exercises (BCEs) andrespiratory muscle training (RMT) have been studied to improve breathlessness. Forexample, BCEs include diaphragmatic breathing (DB), pursed-lip breathing (PLB), relaxationtechniques (RT), and body position exercises (BPEs). BCEs aim to decrease the effort required for breathing and assist relaxation by deeper breathing, which may result in animproved breathing pattern through decreased respiratory rate and reduced breathlessness (10) .

1.3 Inspiratory: Expiratory Ratio

The Inspiratory: Expiratory ratio is the duration of inspiration to the duration ofexpiration. A range of 1:1.5 to 1:2 for an adult is considered acceptable for mechanicalventilation. Ratios of 1:1 or higher may cause hemodynamic complications, whereas ratioslower than 1:2 indicate lower mean airway pressure and fewer associated hazards.The normal I:E ratio is 1:2, meaning that expiration takes twice as long as inspiration. A ratioof 2:1 is seen in clients with COPD because expiration is shorter than inspiration. As asthmais characterized by a (at least partially) reversible airway obstruction, this affects mainlyexpiratory flow (expiration is usually a complete passive process, requiring no respiratorymuscle activity). So in severe asthma (and also in COPD) expiration is prolonged, leading toa decreased I:E ratio. Normal baseline respiratory rate is between 12-16 breaths per minute.

1.4 Background of the study

Breathing pattern and controlled breathing is altered in diseases (I:E ratio is altered from 1:2 to 1:3 or 1:4) which may involve physiological , psychological and biomechanicalfactors. At a physiological level, hyperventilation has been thought to be driven by centraland peripheral chemoreceptors, and cortical drive. Physiologically every cell in the body requires oxygen to survive yet the body's need to rid itself of carbon dioxide is the most important stimulus for breathing in a healthy person. CO_2 is the most potent chemical affecting respiration. Hyperventilation results in altered (CO_2) levels, and this is most commonly seen as lowered end tidal CO_2 (PET CO_2), or fluctuating CO_2 levels, and a slower return to normal CO_2 levels. Breathing pattern changes may occur in a multitude of cases from hypoxia, heart failure, diaphragmatic paralysis, airway obstruction, infection, neuromuscular impairment, trauma or surgery resulting in musculoskeletal impairment and/or pain, cognitive impairment and anxiety, metabolic abnormalities (e.g., diabetic ketoacidosis [DKA], uremia, thyroid dysfunction), peritonitis, drug overdose, and pleural inflammation. Patients with most respiratory diseases have increased respiratory workloads, which may be due to high respiratory rates, stiff lungs, or high airway resistances. As a result of this the breathing pattern is altered. When the patient becomes so exhausted that they can no longer keep up the workload, respiratory failure ensues (11) . In obstructive airway diseases -- such ase.g. asthma, bronchitis or emphysema -- there is a need for a slow respiratory rate, longexpiratory time ratio, and a relatively large tidal volume and breathing waveform patterns that may be quite unique to the individual. By contrast, the patient with so-called restrictive lung disease, e.g. pulmonary fibrosis, or many other diseases that may cause a loss of lung volume without airway obstructive problems of dominant significance, efficient breathing generally requires smaller tidal volumes, a more rapid respiratory rate, and a more rapid expiratory time ratio, again with breathing wave forms that might be quite unique. Regardless of underlying lung disease, when the patient receives assistive breathing with or without the added requirement for aerosol/dust delivery to the lungs, other sets of optimized breathing patterns may be needed for the particular patient, above and beyond the pattern requirement for normal spontaneous breathing. In any of the above noted problems, the expiratory phase is desirably "passive", that is, passive recoil of the elastic lung/chest wall structures force the air out of the patient with maximum ease and efficiency, minimum patient energy expenditure,and minimum increases in lung pressure to thereby avoid so-called "dynamic bronchialCompression" and further restriction to the airflow passages. However, in many airwayobstructive problems, particularly those due to advanced emphysema with an excessively prolonged expiration time, a variable portion of the terminal expiratory phase should be variably "active", that is, utilizing active muscular contracture to force that air out of the lungs. When a person encounters an abnormal breathing situation with different mechanical contraints for efficient breathing, it may require extensive training to modify his establishedhabits and instinctive rhythms (11) . Patients with obstructive and restrictive ventilator abnormalities suffer from dyspnea and exercise limitation. Dyspnea, a complex symptom with multilayered pathophysiology, remains the most distressing symptom for those with progressive obstructive and restrictive lung disease. The breathing patterns of patients with obstructive and restrictive lung disease during exercise are likely to be important contributory factors in the genesis of dyspnea. Obstructive patients are able to maintain or increase their tidal volume (V_T), while restrictive patients quickly become tachypneic with their V_T encroaching on their inspiratory capacity (12) .

1.5 The COPD Breathing Pattern

The person with COPD typically breathes at a relatively rapid rate and with a small breath volume, and usually with a relatively short expiration time. This is due to abnormal mechanical factors within your lungs and chest wall. The lungs are frequently stretched-out near their elastic limit and therefore more effort has to be expended to make the lungs move. The chest wall and chest muscles of breathing are also stretched-out near their elastic limit, and furthermore are involved in the stiffening problem related to the Barrel Chest deformity, thus making the chest wall even harder to move. The result is a small breath volume (called the Tidal Volume), because taking in a larger breath is just too hard to do, and would require too much so-called Work of Breathing. Shortness of breath (Dyspnea) is related to a number of factors, but is most closely related to the Work of Breathing. And because of these smaller breaths, in order to provide enough air, the respiratory rate of breathing must speed up, hence the COPD breathing pattern of rapid and shallow breathing. Respiratory rate is increased above the normal in smokers and in patients with COPD, restrictive lung disease and pulmonary hypertension, but remains normal in asthmatic patients. Inspiratory times (T1) of one second or less often occurred in patients with COPD, restrictive lung disease, and pulmonary hypertension. Smokers and patients with symptomatic asthma, COPD, restrictive lung disease and pulmonary hypertension shows heightened respiratory center drive as reflected by elevated mean inspiratory flow (VT/TI). Fractional inspiratory time is reduced to a variable extent in smokers, symptomatic asthmatic patients and patients with COPD, and is a weak indicator of airways obstruction. Patients with COPD often has major fluctuations of expiratory timing, periodic fluctuations of end-expiratory level, and asynchrony between rib cage and abdominal movements (13). Patients with –chronic obstructive pulmonary disease (COPD) in acute respiratory failure demonstrate a rapid andshallow breathing pattern. A similar breathing pattern is observed in patients who failweaning and in stable patients with hypercapnia or chronic respiratory failure when comparedto healthy subjects. The rapid shallow breathing pattern inevitably results in hypercapnia. Hence, the ventilatory pump fails to maintain adequate alveolar ventilation. The failure of the ventilatory pump may be the result of decreased respiratory muscle capability and/or increased mechanical load (14) .

TABLE 1. Diseases or Conditions That May be Associated With Obstruction to Airflow
Lower Airway Obstruction: Asthma
Chronic bronchitis
Emphysema
Cystic fibrosis
Sarcoidosis
Upper Airway Obstruction: Croup
Laryngotracheobronchitis
Epiglottitis
Various tumors and foreign bodies that may involve theupper airway

TABLE 2. Respiratory Diseases and Conditions Commonly Associated With a Restrictive BreathingPattern.
CENTRAL NERVOUS SYSTEM AND CHEST LUNGS
Polio Pneumonia
Obesity Sarcoidosis
Myasthenia gravis Lung fibrosis
Guillain Barré syndrome
Acute respiratory failure associated with pulmonaryedema
Flail chest (multiple broken ribs) Hyaline membrane disease
Diaphragm paralysis Advanced lung cancer
Spinal cord disease Congestive heart failure
Pickwickian syndrome
Pleural effusion and pleural disease

1.6 Need for breathing control retraining:

Breathing pattern retraining is a technique used by physiotherapists to correct abnormal respiratory mechanics and breathing pattern disorders (18) . Normal breathing is slow, effortless, regular, fluid and quiet with virtually no movement above the diaphragm. Some master breathing retraining quite rapidly, while others may require months of practice. The goals are to change from erratic breathing to slow, regular, rhythmic abdominal breathing and to make this kind of breathing automatic. This shift in breathing results in long-term changes in the nervous system and anxiety symptoms. People with obstructive and restrictive respiratory conditions have “dysfunctional breathing”, which needed to be corrected through breathing retraining. The term “dysfunctional breathing” is not a precise or definable entity. It ascribes causality to a pattern of abnormal breathing that may result at worst in a symptom complex of breathlessness, chest tightness, paraesthesiae, anxiety, and dizziness. This may include overt hyperventilation and hypocapnia but also includes more subtle and subjective features that are difficult to characterise. Dysfunctional breathing (also known as hyperventilation syndrome and disproportionate breathlessness) is a syndrome of excessive breathlessness and other variable somatic symptoms that is sometimes but not always associated with demonstrable hypocapnia. There is an assumption in the paper by Thomas et al thatdysfunctional breathing can be effectively treated after it has been recognized. Hence breathing retraining is given for patients with obstructive and restrictive respiratory conditions (19) .Functional breathing problems have been shown to result in significant morbidity includingrespiratory symptoms such as breathlessness, chest tightness and chest pain, and non- respiratory symptoms such as anxiety, light headedness, and fatigue. Because patients frequently overbreathe or have an increased respiratory rate, this syndrome is often called the “hyperventilation syndrome”. Nevertheless, patients may exhibit other breathing abnormalities such as unsteadiness and irregularity of breathing, frequent sighing, and a predominantly upper chest rather than diaphragmatic respiratory effort. Dysfunctional breathing may, however, be responsive to interventions directed at breathing retraining; improvements have been reported in clinical series and in a randomised controlled trial (28) . Pursed-lip breathing (PLB), and diaphragmatic breathing are breathing retraining strategy often spontaneously employed by patients with COPD to relieve dyspnea. However, despite improvement in gas exchange and efficiency of ventilation, the efficacy of PLB in relieving dyspnea varies greatly among patients (20) .

Thus it can be concluded that -

1. Breathing retraining corrects the I:E ratio through appropriate timing or inspirationand expiration.
2. The work of breathing is reduced as the use of accessory muscles of breathing is less.
3. Through proper inspiration and expiration improves the chest/thoracic expansion.
4. Corrects the level of Pa02 and PaCO2.
5. Improves fitness and prevents unnecessary work of the accessory muscles ofrespiration (sternocleidomastoid, platysmus,trapezius etc).

The main elements of breathing pattern that may be manipulated are :

1. route of breathing (encouraging breathing through the nose rather than the mouth)
2. depth of breathing (aiming to reduce the volume of air breathed in and out),
3. rate of breathing (aiming to reduce the number of breaths taken per minute),
4. airflow velocity (aiming to reduce the speed of airflow in and out,
5. timing of breathing (aiming to breathe out for longer than you breathe in),
6. rhythm of breathing (aiming for a regular breathing pattern without too many deepsighs),
7. primary region of movement (aiming to reduce use of the upper chest and increase useof the lower chest and abdomen).
8. breath holds and pauses (various aims, but used to aid in controlling breathing pattern)

1.7 NEED FOR DEVICING A NEW TOOL

- Cost effectiveness.
- The device helps train breathing control to the patients without any assistance ofphysiotherapist; wherein the model is easily absorbable, understood and replicated.
- Portable and less maintenance.
- A simple but not a complex model.
- Provides bio-feed forward mechanism by certain signals.
- It helps patients learn how to successively breathe slower, shallower and regularly.
- It helps patients with breathing problems regain control of their breathing.
- The device can optimize the variation in the amount of breath hold for a patient.
- To correct the I:E ratio.
- The device tells the individual when to start inspiration and when to start expiration.

Thus, providing patients and indeed clinicians with feed forward mechanism duringrehabilitation can have potential therapeutic effects as it may enable users to gain control ofphysical processes previously considered an automatic response of the autonomic nervoussystem. In doing so it may offer the opportunity to improve accuracy during functional tasks,increase patient engagement in their rehabilitation and reduce the need for ongoing contactwith healthcare professionals to monitor implementation of rehabilitation programmes.

II. Procedure

Construction of the new device - The device consisted of a microcontroller which runs thecode required to connect all the peripherals of the system. The inputs and outputs of thesystem was read and controlled by the microcontroller. There were four buttons to modify theset point values for the inspiration and expiration. The two LED's of green and red colourindicated the breathing pattern(inspiration and expiration respectively)which was followed bythe individual wearing it. The LCD screens showed a bar graph for the the inspiratory and theexpiratory cycle. The LED's continued increasing its brightness with inspiration andexpiration and its brightness decreased with the end of inspiration and expiration. A powermodule provided the regulated power to the whole system(Li-Ion battery provides thepower).

Working of the new device- The respiratory trainer gave visual clues for the start ofinspiration and for the start of expiration. With the green LED turning on, the patient wasasked to inspire for the set duration of time which was set in the device and the brightness ofthe LED's was increased reaching the completion of the inspiratory phase and then fades offwith the red LED turning on, and as the expiratory cycle is completed it fads off. Theinspiratory and expiratory cycle was shown in the LCD screens by a bar graph. The numberof bars was increased with inspiration which thereby gave visual cues to the individualregarding his/her performance of breathing. The bar graph showed the individual theinspiratory and the expiratory cycle. The bar graph gave an idea to the patient that he/sheneed to reach till the upper limit of inspiration and expiration.

III. Statistical Analysis

The statistical test used for the analysis of the result was; paired t test for normally distributed data and Wilcoxon sign rank test for non normally distributed data. Paired t- test was performed for all the thirty samples for the outcome measure respiratory rate and chest expansion(lower), as the data's were normally distributed and correspondingly their mean and p values were recorded. As the study involves before and after measurements for all the five domains, paired t test is thus taken for the study. Changes in the scores in the baseline and after 15-20 minutes of breathing training were recorded. For the outcome measures, Inspiratory:Expiratory ratio, chest expansion(Upper), 6minute walk test(No. of laps and distance covered) and ERV ,Wilcoxon sign rank test was applied as the data's were not normally distributed which was found in Winpepi statistical software through pitman's test(p values were not >.05).

Table 3: shows the means of all the five domains(n-30).

DOMAINS	MEAN		P value
	PRE	POST	
Respiratory rate	20.17	17.53	<0.001
Inspiratory : Expiratory ratio	0.7827	0.483	0.001
Chest expansion Upper Lower	 1.1567 1.07	 1.37 1.3	 <0.001 0.002
Six minute walk test No of laps covered Distance covered	 6.717 201.50	 7.950 238.50	 0.0009 <0.001
Expiratory reserve value	0.763	0.580667	0.083

IV. Results

In this study 30 patients with respiratory disease (both restrictive and obstructive conditions)were taken. All the patients were given breathing training with the new device for 15-20 minutes. Pre and Post assessments were taken with respiratory rate, Inspiratory:Expiratory ratio, chest expansion(upper and lower), 6MWT(laps and distance covered) and ERV(through body plethysmography).For Pre and Post assessment of respiratory rate and chest expansion(lower), paired t test wasapplied as the data's were normally distributed. Normal distribution was checked in WinPepi statistical software through Pitman's test. For I:E ratio, chest expansion(upper), 6MWT(laps and distanance covered) and ERV , Wilcoxon Signed Rank test was applied as the data's were not normally distributed.

V. Discussions

Biofeedback is a widely used method for teaching voluntary control of various physiologicalfunctions by providing instantaneous feedback for variations in physiologicalactivity(Schwartz & Andrasik, 2003). Oonagh M Giggins et al in their paper had mentionedthat biofeedback has been used for many years to assist patients and clinicians duringrehabilitation. Their paper had reviewed the biofeedback applications that were being used inphysical rehabilitation and classified the different types of biofeedback into two maincategories; physiological biofeedback biomechanical biofeedback. The research in the abovementioned field primarily focused on the use of biofeedback in rehabilitation of patients withneurological disorders. EMG biofeedback was by far the most popular form of biofeedback,however newer technologies were investigated for their potential as biofeedback tools. Whilethe evidence to support the use of biofeedback in rehabilitation appears promising, there ishowever a lack of systematic reviews including a large number of RCTs examining thissubject. Further large RCTs and systematic reviews investigating different biofeedbackapplications in different clinical populations are warranted (31) Respiratory biofeedback is delivered by measuring breathing using electrodes or sensorsattached to the abdomen and by converting breathing to auditory and visual signals for theuser. Teaching diaphragmatic breathing in patients with respiratory disease is the mostcommon means of providing respiratory biofeedback. Reports suggest that biofeedbackassisted diaphragmatic breathing and systematic relaxation were equally as effective aspropranolol in reducing the frequency, severity and duration of migraine headaches after sixmonths of treatment. Delk et al. compared diaphragmatic excursion and EMG feedback ofaccessory muscle activity to a control intervention of temperature biofeedback combined withrelaxation therapy in participants with cystic fibrosis. Results of this study revealedsignificant improvements in measures of lung function in the experimental group while thecontrol group showed no change. Biofeedback on breathing exercises has been shown to bean effective treatment for hypertension. Respiratory biofeedbackis used to slow down the respiratory rate and hence promote relaxation. Reports suggest thatbiofeedback of breathing may be efficacious in the treatment of a number of conditions,however more extensive research is required in this field. Feedback usually is given in the form of visual and /or auditory signals derived from physiological recording devices.Biofeedback is an effective technique through which patients train themselves to acquire a setof skills, the learning of which is elaborated through the information given by a biofeedbackapparatus. As a health intervention technique, biofeedback is well known to facilitatetreatment for a wide variety of disorders with a psychosomatic component, including asthma,cardiovascular disorders, hypertension, cephalopathies, anxiety, and duodenal ulcers, and inmany cases, the results obtained have been notably positive (31) .

In the present study too, through the use of visual biofeedback, patients were trained tocorrect their abnormal breathing pattern and thus trained for a normal breathing pattern. Asthe patients with both obstructive and restrictive disorders were taken for the study, most ofthe patients showed functional improvements but there were no physiological improvementsin their disease pattern. Most patients showed improvements through decrement in respiratoryrate, improvement in 6 minute walk test, some showed improvements in chest expansion andinspiratory : expiratory ratio. Six minute walk test(6MWT) showed more of theimprovements than any of the other outcome measures; the distance covered pre and posttreatment with the breathing device was increased in all of the patients. Chest expansion andInspiratory:Expiratory ratio showed very mild improvement. This is due to the reason that,for these outcome measures to improve a long term treatment is necessary. One day treatmentprotocol for 15-20 minutes is insufficient for these parameters to show some outstandingimprovement. Respiratory rate was showed some moderate improvement than chestexpansion and Inspiratory:Expiratory ratio. But the expiratory reserve volume(ERV) was notincreased in most of the patients which signifies air trapping amongst the patients. Theexpiratory reserve volume was increased in nine patients out of the thirty samples selected forthe study. These patients were of mild degree COPD(according to the GOLD criteria) whohad dyspnoea score 1 or 0 according to MMRC grading. Mild degree COPD were able tofollow the proper instructions of breathing training and thus able to execute it efficiently dueto their decreased dyspnea score(MMRC grading). 21(Twenty-one) patients had decreasedERV which means that there was more of air trapping. Out of the 21 (twenty-one) patientswith decreased ERV; 10(ten) were of restrictive conditions and the remaining(11) were ofobstructive conditions. Restrictive condition patients due to their decreased lung compliance ,have decreased thoracic expansion which thereby leads to decreased ERV. The 11(eleven)patients with obstructive conditions , few were COPD and few were asthma with MMRCgrading 2 or 3. These patients , due to their underlying pathology have already trapped air,henceforth decreased ERV.Overall exertional dyspnea in COPD is the result of complex pathohysiological mechanismsincluding dynamic hyperinflation, increased ventilatory demand relative to impaired capacity,hypoxemia, hypercapnia, and neuromechanical dissociation (33) . This decreased ERV in thesepatients can’t corrected in a one-time breathing training for 15-20 minutes; it needs breathingtraining for atleast few days thereby which it might prove to be an effective treatment forsuch kind of patients.Patients with restrictive lung disease display marked, and hitherto unrecognized,abnormalities in breath to-breath variability of breathing (29) , thus patients with restrictivepattern were included in the study; similarly, the patients with obstructive disease pattern arecharacterized with expiratory airflow limitation (30) ; thus to improve their expiratory flow ofair, obstructive patients were included in the study. 6 minute walk distance should change by, 35 m for patients with moderate to severe COPD torepresent an important effect (34) , 6minute walk test(6MWT) correlated with the spirometricparameters in severe and very severe COPD patients. 6MWT may be used to monitorchanges of pulmonary function in these patients (35) . The 6MWT was chosen because it iseasier to administer, better tolerated, and better reflects activities of daily living than otherwalk tests. The 6MWT is a useful measure of functional capacity, targeted at people with atleast moderately severe impairment. It has been widely used for measuring the response totherapeutic interventions for pulmonary and cardiac disease (25) . 6MWT showed significantimprovements in terms of number of laps and distance covered post training with the newvisual bio feedback device.

VI. Conclusion

The application of the the new visual bio feedback device synchronized breathing trainer ortraining breathing control was helpful to the patients with obstructive and restrictive patternof respiratory disorders. The device shows functional improvements amongst the patients butthere were no physiological improvements in the various patients. The device can not alterthe disease pattern of the patients but it can improve the patient functionally.

6.1 CLINICAL IMPLICATIONS

As breathing training plays an important role in the improvement of pulmonary functions, ourstudy focuses on the effectiveness of the new visual bio feedback device synchronizedbreathing trainer amongst the patients with respiratory disorders(both obstructive andrestrictive pattern). Patients can be trained to help in correcting their abnormal breathingpattern without the assistance of any physiotherapist. The patients can perform breathingtraining as part of their home treatment protocol. As the device has a sensory feed forwardmechanism in the form of a vibrator, it helps the patients with visual impairment , to correcttheir breathing pattern and have a proper breathing training. But before training with the newvisual bio feedback device , the patient should clearly understand the proper instructionsgiven by the physiotherapist.

6.2 LIMITATIONS

1. Inability to correlate with the instructions given by the physiotherapist.
2. Obese and claustrophobic patients are unable and unwilling to sit in the bodyplethysmography for taking the reading of ERV(expiratory reserve volume).

6.3 FURTHER SCOPE

The new visual bio feedback device can be compared with conventional breathing retrainingexercises. Two groups can be chosen ; one given conventional breathing retraining exercisesas a control group and the other training with the new visual bio feedback device. Thetreatment can be given for week and then checked for their lung functions whichever isshowing more of the improvements.ce covered) and ERV , Wilcoxon Signed Rank test was applied as the data's were not normally distributed.

References

[1]. Braun.R.S., Clinical Methods: The History, Physical, and Laboratory Examinations 3 rd edition, Boston :Butterworths; 1990. Chapter 43 Respiratory Rate and Pattern

[2]. NHLBI , "How the lung works Clinical trials" July 17 th 2012.

[3]. Smith.C.T, Rowley.J,. "Breathing pattern disorders and physiotherapy: inspiration for our profession". Physical Therapy Reviews, 2011 Volume. 16 page no 75 .

[4]. Yuan.G, Drost.A.N, McIvor.A.R, "Clinical Review Respiratory Rate and Breathing Pattern", 2013; Volume 10, No1 ,page 23.

[5]. Tomich.G.M, França.D.C, Diório.A.C.M, Britto.R.R, Sampaio.R.F and Parreira.V.F. "Breathing pattern, thoracoabdominal motion and muscular activity during three breathing exercises". Brazilian Journal of Medical and Biological Research ,2007 40: 1409-1417 ISSN 0100-879X .

[6]. Sung-min Ha, Oh-yun Kwon, Su-jung Kim, and Sung-dae Choung . "The Importanceof a Normal Breathing Pattern for an Effective Abdominal-Hollowing Maneuver in Healthy People: An Experimental Study". Journal of Sport Rehabilitation, 2014, 23, 12-17.

[7]. Ragnarsdottir.M, Kristinsdottir.K.E. "Breathing Movements and Breathing Patternsamong Healthy Men and Women 20-69 Years of Age Reference values ". Respiration ;2006 ;10.1159/000087456.

[8]. Pryor and Prasad

[9]. Gosselink.R. "Controlled breathing and dyspnea in patients with chronic obstructive pulmonary disease(COPD)." Journal of Rehabilitation Research and Development, 2003;Volume 40, No.5 pages 25-34.

[10]. Borge.R.C, Hagen.B.K, Mengshoel.M.A, Omenaas.E , Moum.T, Astrid Klopstad Wahl. "Effects of controlled breathing exercises and respiratory muscle training in people with chronic obstructive pulmonary disease: results from evaluating the quality of evidence in systematic reviews". BMC Pulmonary Medicine ,2014; 14:184.

[11]. Tobin.M.J; Chadha.T.S; Jenouri.G; Birch.J.S; Gazeroglu.B.H; Sackner.M.A. " Breathing patterns. Diseased subjects". Chest. 1983;84(3):286-294. doi:10.1378/chest.84.3.286

[12]. Sassoon.H.S.C, Hawari.I.F. "Breathing Pattern of Patients with COPD". Yearbookof Intensive Care and Emergency Medicine Volume 1999, 1999, pp 201-206

[13]. Nield.M, Arora.A, Dracup.K, Guy W. Soo Hoo, Christopher B. Cooper."Comparison of breathing patterns during exercise in patients with obstructive and restrictive ventilatory abnormalities". Journal of Rehabilitation Research & Development, Volume,2003 ;40 , No 5, pages 40.

[14]. Wise.J.E ,Wise.G.L. "Respiratory Biofeedback and Performance Evaluation System". 1976; United States Patent.

[15]. Papandrinopoulou.D, Tzouda.V, and Tsoukalas. Review Article "Lung Compliance and Chronic Obstructive Pulmonary Disease". Pulmonary Medicine Volume 2012, Article ID 542769, 6 pages doi:10.1155/2012/542769.

[16]. Brashier.B.B, Kodgul.R. "Risk Factors and Pathophysiology of Chronic Obstructive Pulmonary Disease (COPD)";2012 ;Supplement to Japi Vol. 60.

[17]. Wilkins

[18]. Sardoski

[19]. Dechman.G,Wilson.R.C; "Evidence Underlying Breathing Retraining in People WithChronic Obstructive Pulmonary Disease"; Journal of the American PhysicalTherapy Association; 2004; 84:1189-1197.

[20]. Mayo Clinic Staff. Stress Management; Relaxation Techniques. August 2011.

[21]. Gosselink.M.A.A.R Wagenaar.C.R, Rijswijk.H, Sargeant.J.A, and Decramer.A.L.M;"Diaphragmatic Breathing Reduces Efficiency of Breathing in Patients with Chronic Obstructive Pulmonary Disease"; American Journal of Respiratory and Critical Care Medicine, Vol. 151, No. 4 (1995), pp. 1136-1142; doi: 10.1164/ajrccm/151.4.1136 .

[22]. ATS Statement: Guidelines for the Six-Minute Walk Test Am J Respir Crit Care MedVol 166. pp 111–117, 2002 DOI: 10.1164/rccm.166/1/111.

[23]. Criée.C.P , Sorichter.S, Smith..H.J, Kardos. P, R. Merget.R, Heise.D, Berdel.D,Köhler.D, Magnussen.H, Marek.W, Mitfessel.H, Rasche.K, Rolke.M, Worth.H, Jörres.A.R. "Body plethysmography – Its principles and clinical use". Respiratory Medicine,2011; Volume 105, Issue 7, Pages 957-958.

[24]. Smith.C.T, Rowley.J, ; "Breathing pattern disorders and physiotherapy: inspirationfor our profession"; Discussion Paper ;2011; Physical Therapy Reviews, Vol 16 No.1.; DOI 10.1179/1743288X10Y.0000000025.

[25]. Kate Ann Levin. A.K; "Study design III: Cross-sectional studies"; Evidence-BasedDentistry 2006; 7, 24–25. doi:10.1038/sj.ebd.6400375.

[26]. Kothari

[27]. Wilkins

[28]. Chest expansion
[29]. Kothari
[30]. Giggin.M.O, Persson.M.U and Caulfield.B; Biofeedback in rehabilitation; Giggins etal. Journal of NeuroEngineering and Rehabilitation 2013, 10:60.
[31]. Liu.Z.G, Huang.Y.B, S.M, and Wang.L; "A Wearable Respiratory BiofeedbackSystem Based on Generalized Body Sensor Network"; Telemedicine and E-Health June 2011; Page 348.
[32]. Antoniu.A.S; "Descriptors of dyspnea in obstructive lung Diseases, MultidisciplinaryFocus on: Dyspnea"; Multidisciplinary Respiratory Medicine; 2010; 5(3): 216-219.
[33]. Enright.L.P; "The Six-Minute Walk Test"; Respiratory Care 2003;48(8):783–785.
[34]. Chen H.C, Liang BM.L, Tang YJ, Xu ZB, Wang K, Yi Q, Ou XM, Feng YL;"Relationship between 6-minute walk test and pulmonary function test in stable chronic obstructive pulmonary disease with different severities"; Chinese Medical Journal . 2012 Sep;125(17):3053-8.
[35]. C.K and Cho.S.M; "The Effects on the Pulmonary Function of Normal AdultsProprioceptive Neuromuscular Facilitation Respiration Pattern Exercise"; Journal of Physical Therapy Science; Oct 2014; 26(10): 1579–1582.
[36]. R.J.Arnoldus, Gestel.V, Kohler.M, Steier.J, Teschler.S, Russi.W.Erich, Teschler.H."The Effects of Controlled Breathing during Pulmonary Rehabilitation in Patients with COPD". Respiration 2012; 10.1159/000324449.
[37]. Martin S, Volkan A, Jana U, Katja P, Michael MW. A Pilot study on the effects ofheart rate, variability biofeedback in patients with depression and in health subjects. Appl Psycholphysiol Biofeedback 2008;33:195–201.
[38]. Terri LZ, Kristin WS, Richard NG. The effects of respiratory sinus arrhythmiabiofeedback on heart rate variability and posttraumatic stress disorder symptoms: A pilot study. Appl Psychophysiol Biofeedback 2009;34:135–143.
[39]. Moore SK. Calm in your palm: Biofeedback device promises to reduce stress.IEEESpectr 2006;43:60.
[40]. Chulsung P, Chou PH. Eco: Ultra-wearable and expandable wireless sensorplatform. Presented at IEEE Workshop on Wearable and Implantable Body Sensor Networks. 2006;161–165 .
[41]. ATS statement: guidelines for the six-minute walk test. ATS Committee onProficiency Standards for Clinical Pulmonary Function Laboratories. Am J RespirCrit Care Med 2002;166(1):111–117.
[42]. Solway S, Brooks D, Lacasse Y, Thomas S. A qualitative systematic overview of themeasurement properties of functional walk tests used in the cardiorespiratory domain. Chest 2001;119(1):256–270.
[43]. Gibbons WJ, Fruchter N, Sloan S, Levy RD. Reference values for a multiplerepetition 6-minute walk test in healthy adults older than 20 years. J Cardiopulm Rehabil 2001;21(2):87–93.
[44]. Parreira VF, Tomich GM, Britto RR, Sampaio RF. Assessment of tidal volume andthoracoabdominal motion using volume and flow oriented incentive spirometers in healthy subjects. Braz J Med Biol Res 2005; 38: 1105-1112.
[45]. Mannino DM, Buist AS. Global burden of COPD: risk factor prevalence, and futuretrends. Lancet 2007;370:765-73.
[46]. Viegi G, Pistelli F, Sherrill DL et al Definition, epidemiology and natural history ofCOPD. SERIES ''Comprehensive Management Of End-Stage COPD'' Edited by N.Ambrosino and R. Goldstein Number 1 in this Series. Eur Respir J 2007;30:993-1013.
[47]. Mannino DM, Watt G, Hole D, et al. The natural history of chronic obstructivepulmonary disease. Eur Respir J 2006;27:627-43.
[48]. GOLD: Global initiative for chronic obstructive lung disease. Global strategy for thediagnosis, managment, and prevention of chronic obstructive pulmonary disease.
[49]. Borge CR, Wahl AK, Moum T: Association of breathlessness with multiplesymptoms in chronic obstructive pulmonary disease. J Adv Nurs 2010, 66(12):2688–700.
[50]. Tsiligianni I, Kocks J, Tzanakis N, Siafakas N, van der Molen T: Factors thatinfluence disease-specific quality of life or health status in patients with COPD: areview andmeta-analysis of Pearson correlations. Prim Care Respir J 2011,20:257–268.
[51]. The Cochrane Collaboration. http://www.cochrane.org/about-us/evidence-based-healthcare.Accessed June 18 2012.
[52]. O'Donnell DE, Webb KA. Mechanisms of dyspnea in COPD. In: Mahler D,O'Donnell DE, eds. Dyspnea, mechanisms, measurement and management. BocaRaton, FL, Taylor and Francis Group 2005:29-58.
[53]. Lougheed MD, O'Donnell DE. Dyspnea in asthma. In: Mahler D, O'Donnell DE, eds.Dyspnea, mechanisms, measurement and management. Boca Raton, FL, Taylor andFrancis Group,2005:59-86.
[54]. Lougheed MD, Fisher T, O'Donnell DE. Dynamic hyperinflation duringbronchoconstriction in asthma: implications for symptom perception. Chest2006;130:1072-1081.
[55]. Manning HL, Schwartzstein RM. Respiratory sensations in asthma: physiological andclinical implications. J Asthma 2001;38:447-460.
[56]. Lacasse Y, Brosseau L, Milne S, et al. Pulmonary rehabilitation for chronicobstructive pulmonary disease. Cochrane Database Syst Rev 2004; 4: CD003793.
[57]. Nici L, Donner C, Wouters E, et al. American Thoracic Society/EuropeanRespiratory Society statement on pulmonary rehabilitation. Am J Respir Crit CareMed 2006; 173: 1390–1413.
[58]. Celli BR, Cote CG, Marin JM, et al. The body-mass index, airflow obstruction,dyspnea, and exercise capacity index in chronic obstructive pulmonary disease. NEngl J Med 2004; 350: 1005–1012.
[59]. Garcia-Aymerich J, Farrero E, Felez MA, Izquierdo J, Marrades RM, Anto JM. Riskfactors of readmission to hospital for a COPD exacerbation: a prospective study.Thorax 2003; 58: 100–105.
[60]. Wise RA, Brown CD. Minimal clinically important differences in the six-minute walktest and the incremental shuttle walking test. COPD 2005; 2: 125–129.
[61]. Cahalin LP, Braga M, Matsuo Y, Hernandez ED. Efficacy of diaphragmatic breathingin persons with chronic obstructive pulmonary disease: a review of the literature. JCardiopulm Rehabil. 2002;22:7–21.
[62]. Global Initiative for Chronic Obstructive Lung Disease. Global Strategy for theDiagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease:NHLBI/WHO Workshop Report. Rockville, Md: National Institutes of Health,National Heart, Lung, and Blood Institute; April 2001. NIH Publication No. 2701.
[63]. Morgan MD, Singh S, Calverley PM, et al. British Thoracic Society statement onpulmonary rehabilitation. Thorax 2001;56:827–34.
[64]. Opat AJ, Cohen MM, Bailey MJ, et al. A clinical trial of the Buteyko breathingtechnique in asthma as taught by a video. J Asthma 2000;37:557–64.
[65]. Fabbri LM, Luppi F, Beghe B, Rabe KF. Complex chronic comorbidities of COPD.Eur Respir J 2008;31:204–212.
[66]. Fabbri LM, Rabe KF. From COPD to chronic systemic inflammatory syndrome?Lancet 2007;370:797–799.
[67]. Fabbri LM, Beghe B, Agusti A Cardiovascular mechanisms of death in severe COPDexacerbation: time to think and act beyond guidelines. Thorax 2011;1e3.
[68]. Li AM, Yin J, Yu WC, et al. The six—minute walk test in healthy children: reliabilityand validity. Eur Respir J. 2005;25:1057–60.

[69]. Lammers AE, Hislop AA, Flynn Y, Haworth SG. The 6- minute walk test: normalvalues for children of 4–11 y of age. Arch Dis Child. 2008;93:464–8.
[70]. Li AM, Yin J, Au JT, et al. Standard reference for the six-minute walk test in healthychildren aged 7 to 16 y. Am J Respir Crit Care Med. 2007;176:174–80.
[71]. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med2002, 166:111–117.
[72]. Enright PL: The six-minute walk test. Respir Care 2003, 48:783–785.
[73]. Rasekaba T, Lee AL, Naughton MT, Williams TJ, Holland AE: The six-minute walktest: a useful metric for the cardiopulmonary patient. Intern Med J 2009, 39:495–501.
[74]. Brown CD, Wise RA: Field Tests of Exercise in COPD: The Six-Minute Walk Testand the Shuttle Walk Test. COPD: Journal of Chronic Obstructive Pulmonary Disease2007, 4:217–223.
[75]. Chetta A, Zanini A, Pisi G, Aiello M, Tzani P, Neri M, Olivieri D: Reference valuesfor the 6-min walk test in healthy subjects 20–50 years old. Respir Med 2006,100:1573–1578.
[76]. Casanova C, Celli BR, Barria P, Casas A, Cote C, de Torres JP, Jardim J, Lopez MV,Marin JM, Montes de Oca M, et al: The 6-min walk distance in healthy subjects:reference standards from seven countries. Eur Respir J 2011, 37:150–156.
[77]. Miyamoto S, Nagaya N, Satoh T, Kyotani S, Sakamaki F, Fujita M, Nakanishi N,Miyatake K: Clinical correlates and prognostic significance of sixminute walk test inpatients with primary pulmonary hypertension. Comparison with cardiopulmonaryexercise testing. Am J Respir Crit Care Med 2000, 161:487–492.
[78]. Masa JF, Corral J, Martin MJ, et al. Assessment of thoracoabdominal bandsto detectrespiratory effort-related arousal. Eur Respir J 2003; 22: 661–7.
[79]. Celli BR, MacNee W, and committee members; on behalf of the ATS/ ERS TaskForce. Standards for the diagnosis and treatment of patients with COPD: a summaryof the ATS/ERS position paper. Eur Respir J 2004;23:932–946.
[80]. Mahler DA. Measurement of dyspnea: clinical ratings. In: Mahler DA, O'DonnellDE, editors. Dyspnea: mechanisms, measurement, and management, 2nd ed. NewYork: Taylor & Francis; 2005. pp.147–165.
[81]. Celli BR, MacNee W, and committee members; on behalf of the ATS/ ERS TaskForce. Standards for the diagnosis and treatment of patients with COPD: a summaryof the ATS/ERS position paper. Eur Respir J 2004;23:932–946.
[82]. Mahler DA. Measurement of dyspnea: clinical ratings. In: Mahler DA, O'DonnellDE, editors. Dyspnea: mechanisms, measurement, and management, 2nd ed. NewYork: Taylor & Francis; 2005. pp.147–165.
[83]. "Global strategy for the diagnosis, management, and prevention of chronic obstructivepulmonarydisease (GOLD)," 2011.
[84]. J. B. West, Pulmonary Pathophyiology: The Essentials, vol. 52, Lippincott Williamsand Wilkins, Baltimore, MD, USA, 6 th edition, 2007.
[85]. L. Trupin, G. Earnest, M. San Pedro et al., "The occupational burden of chronicobstructive pulmonary disease," European Respiratory Journal, vol. 22, no. 3, pp.462–469, 2003.
[86]. M. C. Matheson, G. Benke, J. Raven et al., "Biological dust exposure in theworkplace is a risk factor for chronic obstructive pulmonary disease," Thorax, vol. 60,no. 8, pp. 645–651, 2005.
[87]. M. Ezzati, "Indoor air pollution and health in developing countries," The Lancet, vol.366, no. 9480, pp. 104–106, 2005.
[88]. E. G. Tzortzaki and N. M. Siafakas, "A hypothesis for the initiation of COPD,"European Respiratory Journal, vol. 34, no. 2, pp. 310–315, 2009.
[89]. P. T. Macklem, "The pathophysiology of chronic bronchitis and emphysema,"Medical Clinics of North America, vol. 57, pp. 669–679, 1973.
[90]. D. E. O'Donnell and K. A. Webb, "Exercise," in Chronic Obstructive PulmonaryDisease, P. M. A. Calverley,W. MacNee, N. B. Pride, and S. I. Rennard, Eds., pp. 243269, Arnold, London, UK, 2nd edition, 2003.
[91]. J. E. Cotes, D. J. Chinn, and M. R. Miller, Lung Function, Blackwell Publishing, 6thedition.
[92]. Pellegrino R, Viegi G, Brusasco V, et al. Interpretative strategies for lung functiontests. Eur Respir J. 2005;26(5):948–968.

Dr. Dony Kotoky Sarma(PT)"Efficiency Of New Visual Biofeed Back Device – Synchronized Breathing Trainer – For Training Breathing Control " *International Journal of Engineering Science Invention (IJESI)*, Vol. 09(01), 2020, PP0 01-10