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The Effect of Therapeutic Breathing Exercises and Pranayama on Forced Vital Capacity and Forced Expiratory Volume of COPD Patients

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Abstract: ***Purpose: To investigate the effect of therapeutic breathing exercises and pranayama on forced vital capacity and forced expiratory volume of COPD patients. Methods: 30 patients aged 40 - 50 years suffering from COPD (Chronic bronchitis) and under treatment process of chronic bronchitis at S. S. hospital, IMS, BHU, Varanasi, India.30 COPD patients was randomly divided in three equal group i. e., control, therapeutic breathing exercises and pranayama training exercise group, each group having 10 COPD patients. The Pre Test - Post Test randomized group design was used for the study. The Pulmonary function testing (PFT) was used to measure forced vital capacity (FVC) and forced expiratory volume (FEV_1) of COPD patients and score of subjects was recorded in liters. The therapeutic breathing exercises group and pranayama training group was taken 6 weeks therapeutic breathing exercises and pranayama training with our daily life activity and control group was performed our daily life activity without any specific training program. Results: The analysis of covariance (ANCOVA) test was performed to investigate the effect of therapeutic breathing exercises and pranayama on forced vital capacity (FVC) and forced expiratory volume (FEV_1) variables between - within groups two times (before and after treatment), using the least significance difference (LSD) confidence interval adjustment method as post - hoc. The adjusted posttest mean and standard error of mean, for forced vital capacity (FVC) of CG 1.86±0.37, TBE 2.26±0.36 & PT 2.15±0.37 and for forced expiratory volume (FEV_1) of CG 1.28±0.03, TBE 1.71±0.03 & 1.69±0.03 respectively. The results of the study showed that there is significant effect of therapeutic breathing exercises and pranayam training on forced vital capacity (FVC) and forced expiratory volume (FEV_1) of COPD Patients. Conclusion: The therapeutic breathing exercise and pranayama training improves forced vital capacity (FVC) and forced expiratory volume (FEV_1) of COPD Patients after 6 weeks of training program.***

Keywords: Pulmonary Function Test, Therapeutic breathing exercise, Pranayama, COPD

1. Introduction

COPD is a major and increasing global health problem, which is currently the 4th commonest cause of death and predicted to become the 5th commonest cause of disability in the world by 2020. While there have been major advance in the understanding and management of Asthma, COPD has been relatively neglected and there are no current therapies that reduce the inevitable progression of this disease. (Cazzola, Celli, Dahl, & Rennard, 2005, p. 01) Chronic Obstructive Pulmonary disease is a major and growing cause of morbidity and mortality. COPD is characterized by progressive and not fully reversible airflow limitation, as measured by the forced expiratory volume (FEV_1) in 1 second. The airflow limitation is associated with a chronic inflammatory process in the airways and lung parenchyma in response to noxious particles or gases in particular tobacco smoking. (Hanania & Sharafkhaneh, 2011, p. 02) The current global initiative for chronic obstructive lung disease classification system for COPD uses post bronchodilator FEV_1 as a major factor in classification of disease severity and in practice this variable makes up a significant part of the case definition for COPD. (Barnes, Drazen, Rennard, & Thomson, 2009, p. 59)

COPD includes chronic obstructive bronchiolitis with fibrosis and obstruction of small airways, and emphysema with enlargement of airspaces and destruction of lung parenchyma, loss of lung elasticity and closure of small airways. (Cazzola, Celli, Dahl, & Rennard, 2005, p. 02) In patients with serve COPD expiratory airflow limitation is observed at all lung volumes and often occurs even when there is a minimal expiratory effort; in these patients expiratory airflow limitation occurs on expiration with each breath. (Barnes, Drazen, Rennard, & Thomson, 2009, p. 59) The presence of systematic inflammation in COPD has been linked to a variety of complications, including weight loss, cachexia, osteoporosis and cardiovascular diseases. Moreover, elevation of acute - phase proteins in COPD patients suggests that individuals with increased systematic inflammatory markers, such as fibrinogen or c - reactive protein (CRP), experience an accelerated decline in lung function and are at increased risk of hospitalization for COPD. (Hanania & Sharafkhaneh, 2011, p. 02)

Breathing results from inspiratory and expiratory muscle contraction and relaxation. The muscle action and therefore the rate, depth and rhythm of breathing is controlled by the brain and nervous system and is tightly coupled to the body's overall need for oxygen and the subsequent production of energy and carbon dioxide. The coordinated control of respiratory muscles, especially during exercise, is a very complex. (Plowman & Smith, 2014, pp. 274-275) During exercise capillary gas exchange at the alveoli and muscle tissue increases to meet the greater needs for oxygen delivery and carbon dioxide removal. To increase capillary gas exchange, pulmonary ventilation increases under the control of all factors. To augment gas exchange at the

alveoli and tissue must also increase. (Kraemer, Fleck, & Deschenes, 2012, p. 185) The oxygen cost of breathing during whole body graded exercise up to maximum. The left panel indicates the effects of increasing minute ventilation on the oxygen cost of breathing expressed as a percentage of the total exercise oxygen consumption. The right panel illustrates the influence of increasing minute ventilation on the oxygen cost per liter of air breathed per minute. The oxygen requirement of breathing remains relatively small at rest and during light to moderate exercise. (McArdle, Katch, & Katch, 2010, p. 296)

Therapeutic exercise is the systematic performance or execution of planned physical movements, postures or activities intended to enable the patient to; Remediate or prevent impairments, Enhance function, Reduce risk, Optimize overall health, Enhance fitness and wellbeing. Therapeutic exercise may include aerobic and endurance conditioning and reconditioning; agility training; balance training, both static and dynamic; body mechanics training; breathing exercises and coordination exercises. (Bandy & Sanders, 2013, p. 05) Breathing exercise are fundamental interventions for the prevention or comprehensive management of impairments related acute or chronic pulmonary disorders. COPD (Chronic bronchitis, emphysema asthma) or cystic fibrosis, for patients with a high spinal cord lesion, for patients who have undergone thoracic or abdominal surgery and are at high risk for acute pulmonary complications, or for patients who must remain in bed for extended period of time. (Kisner & Colby, 2002, p. 861) The body has a sophisticated system to control breathing that is constantly assessing and adapting to meet the physiologic demands of the body. These demands change based on a number of reasons such as disease, drugs, age, exercise, sleep, etc., Afferent signals relating to respiratory effort, arterial carbon dioxide pressure ($Paco_2$), arterial oxygen pressure (Pao_2), work of breathing and fatigue, arise with each breath and are sent to the brain for processing. (Bandy & Sanders, 2013, pp. 344-345) Apnea is a temporary halt in breathing. Tachypnea is rapid, shallow breathing that indicates respiratory distress. Bradypnea is considered respiration slower than 12 breaths per minute. Dyspnea describes shortness of breath or labored breathing abd is seen in numerous cardiopulmonary disorders. (Bandy & Sanders, 2013, p. 346)

Pranayama is more than just “breath work”, as it is commonly misinterpreted. It is a series of techniques through which life force energy is stimulated, expanded, and balanced with the systematic controlling of the breath. (Givens, 2020, p. 02) The word pranayama is conjunction of the two Sanskrit words Prana and Ayama. Prana refers to the animating life force energy within all things. When prana is rich in supply, your system is energized, and you are balanced psychologically. (Givens, 2020, p. 02) Prana is the vital force that sustains not only the body, but also creation at every level. (Saraswati, 2009, p. 03) Ayama is a verb that means to “stretch” or “extend” in reference to the action of prana. Pranayama means to “extend life force energy” to make you more vital, clear mind and energized. (Givens, 2020, p. 02)

2. Methods

Study participants

For this study included 30 patients aged 40 - 50 years suffering from COPD (Chronic bronchitis) and under treatment process of chronic bronchitis at S. S. hospital, IMS, BHU, Varanasi, India. Before the initiation of the study, the study protocol and related documents was reviewed and approved by Institutional ethical committee, Institute of Medical Science (IMS), Banaras Hindu University, Varanasi, India. In the study, only male COPD patients was selected as a subject and having the stage of one and two chronic bronchitis. Additionally, patients were permitted to take our medicine, which is prescribed by the doctor.30 COPD patients was randomly divided in three equal group i. e., control, therapeutic breathing exercises and pranayama training group, each group having 10 COPD patients. The Pre Test - Post Test randomized group design was used for the study.

Functional Test

Control, Therapeutic breathing exercises and pranayama training group were assigned at random to the participants. The COPD patients were informed and given sufficient time to familiarize themselves with the test procedure. The Pulmonary function testing (PFT) was used to measure forced vital capacity (FVC) and forced expiratory volume (FEV_1) of COPD patients and score of subjects was recorded in liters. (Bandy & Sanders, 2013, p. 346) The Pulmonary function test was conduct on Control, Therapeutic breathing exercises and pranayama training group before and after treatment.

Training Protocol

The therapeutic breathing exercises group and pranayama training group was taken 6 weeks therapeutic breathing exercise and pranayama training with our daily life activity and control group was performed our daily life activity without any specific training program. In therapeutic breathing exercises, diaphragmatic breathing, segmental breathing, posterior basal expansion, pursed lip breathing, preventing and relieving episodes of dyspnea, relaxation breathing, positive expiratory pressure breathing, respiratory resistance training, glossopharyngeal breathing performed by patients with the help of experts. In pranayama training, Kapalbhati, Nadi Shodhana, Ujjayi, Bhramari, Bhastrika performed by patients with the help of experts.

Statistical Procedure

The statistical package for the social sciences was used to analyze the data (SPSS Software, Version 16.0). The alpha value has been set to 0.05. Mean and Standard deviation were calculated. The Shapiro - Wilk test was used to determine normality of data. (Chan, 2003) The analysis of covariance (ANCOVA) test was performed to investigate the effect of therapeutic breathing exercises and pranayama training on forced vital capacity (FVC) and forced expiratory volume (FEV_1) variables between - within groups two times (before and after treatment), using the least significance difference (LSD) confidence interval adjustment method as post - hoc. (Verma, 2011, pp. 172-173)

3. Results

Table 1: Demographic Characteristics of the COPD Patients

Group		CG N=10 X±SD	TBE N=10 X±SD	PT N=10 X±SD
Age (year)		44.80±2.82	45.60±2.75	45.00±2.44
Body weight (kg)		62.70±5.16	63.60±4.37	65.00±3.33
FVC	Before treatment	1.81±0.23	1.86±0.27	1.89±0.27
	After treatment	1.83±0.23	2.27±0.21	2.18±0.26
FEV_1	Before treatment	1.24±0.25	1.27±0.18	1.27±0.20
	After treatment	1.27±0.23	1.73±0.12	1.70±0.16

Abbreviations: X - Mean, SD - Standard Deviation, FVC - forced vital capacity, FEV_1 - forced expiratory volume, CG - Control Group, TBE - Therapeutic Breathing Exercises group, PT - Pranayama Training group

The result of table 1 displays the mean and standard deviation of age, body weight, forced vital capacity (FVC) and forced expiratory volume (FEV_1). The mean and standard deviation of age of CG 44.80±2.82, TBE 45.60±2.75 & PT 45.00±2.44. The mean and standard deviation of body weight of CG 62.70±5.16, TBE 63.60±4.37 & PT 65.00±3.33. The mean and standard deviation of before treatment of forced vital capacity (FVC) of CG 1.81±0.23, TBE 1.86±0.27 & PT 1.89±0.27. The mean and standard deviation of after treatment of forced vital capacity (FVC) of CG 1.83±0.23, TBE 2.27±0.21 & PT 2.18±0.26. The mean and standard deviation of before treatment of forced expiratory volume (FEV_1) of CG 1.24±0.25, TBE 1.27±0.18 & PT 1.27±0.20. The mean and standard deviation of after treatment of forced expiratory volume (FEV_1) of CG 1.27±0.23, TBE 1.73±0.12 & PT 1.70±0.16. (Chan, 2003)

The Shapiro - Wilk test revealed that forced vital capacity and forced expiratory volume data had a normal distribution. The characteristics of the COPD Patients did not differ significantly among three training group ($p>0.05$). At baseline, there were no significant difference in forced vital capacity (FVC) and forced expiratory volume (FEV_1) among groups ($p>0.05$). (Chan, 2003)

Table 2: Comparison of forced vital capacity (FVC) and forced expiratory volume (FEV_1) test values before and after treatment within and between groups

Variables	CG APM±SEM	TBE APM±SEM	PT APM±SEM	Between treatment comparison
FVC	1.86±0.37	2.26±0.36	2.15±0.37	F (2, 26) =31.694, $p<0.001$, $\eta p2=0.709$, 1 - β= 1.00
FEV_1	1.28±0.03	1.71±0.03	1.69±0.03	F (2, 26) =58.908, $p<0.001$, $\eta p2=0.819$, 1 - β=1.00

Abbreviations: APM - Adjusted Post test mean, SEM - Standard error of mean, FVC - forced vital capacity, FEV_1 - forced expiratory volume, CG - Control Group, TBE - Therapeutic Breathing Exercises group, PT - Pranayama Training group, ηp2: Partial eta squared, 1 - β: Observed power.

The results from table 2, the F value for the within subject factor "three treatment group" was significant for forced vital capacity (FVC) (F (2, 26) =31.694, $p<0.001$, $\eta p2=0.709$, 1 - β= 1.00). It indicate that the therapeutic breathing exercises and pranayama training improves forced vital capacity (FVC) of COPD patients. (Field, 2009, p. 405) The $\eta p2=0.709$ is indicates that 70.9% effects of TBE and PT on forced vital capacity (FVC). (Gamst, Meyers, & Guarino, 2008, pp. 454-460)

The F value for the within subject factor "three treatment group" was significant for forced expiratory volume (FEV_1) (F (2, 26) =58.908, $p<0.001$, $\eta p2=0.819$, 1 - β=1.00). It indicates that the therapeutic breathing exercises and pranayama training improves forced expiratory volume (FEV_1) of COPD patients. (Field, 2009, p. 405) The $\eta p2=0.819$ is indicates that 81.9% effects of TBE and PT on forced expiratory volume (FEV_1). (Gamst, Meyers, & Guarino, 2008, pp. 454-460)

Table 3: Pairwise comparison of forced vital capacity (FVC) and forced expiratory volume (FEV_1) among three treatment group

Variable	Pair (three treatment group)	Mean difference
FVC	TBE versus CG	0.400 ($p<0.001$) *
	TBE versus PT	0.114 ($p<0.035$) *
	PT versus CG	0.286 ($p<0.001$) *
FEV_1	TBE versus CG	0.430 ($p<0.001$) *
	TBE versus PT	0.024 ($p=0.599$)
	PT versus CG	0.407 ($p<0.001$) *

*: p value for difference between treatment. Abbreviations: FVC - forced vital capacity, FEV_1 - forced expiratory volume, CG - Control Group, TBE - Therapeutic Breathing Exercises group, PT - Pranayama Training group

The pairwise comparison table 3 among three treatment group for forced vital capacity (FVC) reveals that TBE versus CG, TBE versus PT and PT versus CG were found significant difference among themselves. TBE have more effective compare to PT in forced vital capacity (FVC) of COPD patients. (Chan, Quantitative data Parametric & Non parametric Tests, 2003)

Table 3 reveals that pairwise comparison among three treatment group for forced expiratory volume (FEV_1), TBE

versus CG and PT versus CG were found significant difference among themselves. TBE versus PT no significant difference was observed. It is indicates that TBE and PT have show similar effect on forced expiratory volume (FEV_1) of COPD patients. (Chan, Quantitative data Parametric & Non parametric Tests, 2003)

4. Discussion

The aim of the study was to investigate the effect of therapeutic breathing exercises and pranayama on forced vital capacity (FVC) and forced expiratory volume (FEV_1) of COPD patients. The results of the study showed that there was significant effect of therapeutic breathing exercises and pranayama on forced vital capacity (FVC) and forced expiratory volume (FEV_1) of COPD patients. In case of forced vital capacity (FVC), therapeutic breathing exercises shows better effect compare to pranayama. Therapeutic breathing exercises and pranayama have similar effect on forced expiratory volume (FEV_1) of COPD patients. COPD includes chronic bronchitis, small airway disease and emphysema, and is characterized by airways obstruction that is fixed or only partially reversible. (Barnes, Drazen, Rennard, & Thomson, 2009, p. 09) Work of breathing clearly contributes to development of respiratory failure during exacerbations of COPD. It is the amount of force needed to move a given volume of air into the lung with a relaxed chest wall. Obstructive airways disease may raise respiratory work requirements excessively due to the pressure of "intrinsic positive end expiratory" pressure and hyperinflation and this is the most common cause of respiratory muscle fatigue. (Lynes, 2007, p. 89) The characteristic impact of COPD on the pulmonary system is the inability to remove air from the lungs effectively, which is turn affects the ability of respiratory system to transport oxygen in lungs. (Kisner & Colby, 2002, p. 875)

Therapeutic breathing and Pranayama exercise the muscle of respiration and the lungs through the processes of deep, rapid or slow breathing, the chest is opened to its fullest extent and the lungs are stretched to the utmost. This strengthens the respiratory muscles and makes the lungs more elastic, resulting in a healthier process of respiration. During therapeutic breathing and parayama exercises one does not absorb a larger quantity of oxygen. In fact, the amount of oxygen absorbed during a round of therapeutic breathing and pranayam exercises is less than the amount absorbed during normal respiration. The total intake of air being smaller in therapeutic breathing and pranayama exercises, the absorption of oxygen is also smaller. However, the practices allow more time for oxygen to mix with the blood flow and for the system to eliminate waste through the breath and blood. The training given to the respiratory organs and muscles during the therapeutic breathing and pranayama practice prepares them to work efficiently all through the day. (Saraswati, 2009, p. 129)

Therapeutic breathing exercises and pranayama may affect and possibly alter a patient's rate and depth of ventilation these interventions may not necessarily have any impact on gas exchange at the alveolar level or an oxygenation. Breathing exercise and pranayama should be only one aspect of management to improve pulmonary status and to increase a patient's overall endurance and function during daily living activity. (Kisner & Colby, 2002, p. 861)

Breathing exercises and pranayama training progressively increase the resistance of breathing through a device. The resistance to breathing causes the diaphragm and accessory muscles of inspiration to work harder to fill the lungs with air. As the diaphragm becomes stronger, the ability to breathe at the lower resistance level becomes easier. The level of resistance is increased to apply a new load on the inspiratory muscles. As the diaphragm becomes stronger, the time to fatigue during normal moderate activities should increase. The COPD patients exercise tolerance should increase as well. Expiratory muscle recruitment is thought to benefit the overall respiratory systems. The effect the abdominal muscles have on expiration can be easily demonstrated in normal subjects. The flow rate of exhaled air is greatly increased when these muscles are contracted during the expiratory phase. Strengthening the expiratory muscles will reduce the end expiratory lung volume. By reducing this volume at the end of expiration, the diaphragm is allowed to return to a more natural position. Thus, the diaphragm lengthens and is able to provide a greater degree of contraction during inspiration. (Bandy & Sanders, 2013, p. 349)

A study by Natasha shetty, Stephen Rajan Samuel, Gopala Krishna Alaparthi, Sampath Kumar Amaravadi, Abraham M. Joshua & Shivanand Pai. (2020) reported that effect of diaphragmatic breathing exercises, volume and flow-oriented incentive spirometry on pulmonary function and maximal respiratory pressures in patients with stroke compared to the effects of the three interventions and also supported the results of this study. The study revealed that all three interventions were successful in enhancing the pulmonary function and maximal respiratory pressure when respiratory muscle training is given for five days in acute stroke subjects. diaphragmatic breathing exercise works on the principle of increasing diaphragmatic descent during deep inspiration to increase collateral ventilation and diaphragmatic excursion, leading to an increase in pulmonary capacities, but the adherence to this technique is least because there is no visual feedback and therefore patients do not practice it as often as required.

Another study by Ferdousi S., Afreen KN., & Algin S. (2018) reported that 3 months slow breathing exercise improves forced vital capacity and forced expiratory volume in patients with major depressive disorder and also supported the results of this study. In this study, lack of significant change in FVC, FEV1, and FVC/FEV1 in MDD patients after 3 months of treatment with anti-depressive drugs only suggests that anti depressive drug have no apparent effect of on lung function. Slow breathing exercise is a type of yogic breathing exercise which is a well-studied breathing technique used to improve lung function in healthy subjects and also have shown a promise for such improvement in lung function in some pulmonary diseases.

Another study by Sangeeta Singh & J. S. Tripathi (2018) already reported that therapeutic exercise improves force vital capacity of person with COPD and also supported the results of this study. In this study, the improvement in

pulmonary function can be attributed to practice of therapeutic breathing exercise and parayama. These practices increase muscular strength and endurance of muscles in the thoracic cage, in turn improving the lung performance. Practice of therapeutic exercise and pranayama helps in reducing the heart rate and blood pressure. It improves blood supply to organs, thereby increasing oxygenation, and removing the metabolic waste from the body. Therapeutic exercise and pranayama increase oxygen saturation, enhances the aerobic metabolism.

A study by Shankarappa V., Prashanth P., Nachal Annamalai & Varun Malhotra (2012) reported that the short-term effect of pranayama can be used as a lung strengthening tool to treat many lungd diseases and also supported the results of this study.

Some potential limitations of researchers should be acknowledged. The researchers felt that there was a limitation of sample size in the study. Further studies with large sample size should attempt to replicate current findings.

5. Conclusions

The therapeutic breathing exercises and pranayama improves forced vital capacity (FVC) and forced expiratory volume (FEV_1) of COPD Patients after 6 weeks of training program.

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