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Original Article

Physiotherapy Section

Comparison of Respiratory Proprioceptive Neuromuscular Facilitation and Segmental Breathing on Pulmonary Functions, Dyspnoea and Exercise Tolerance in COPD Patients: A Comparative Study

PANKAJ PRAJAPATI[1], SONIA PAWARIA[2], NEHA REYLACH[3]

ABSTRACT

Introduction: Chronic Obstructive Pulmonary Disease (COPD) is a preventable and treatable disease marked by airflow limitation, destruction of lung parenchyma and other associated respiratory symptoms (e.g., dyspnoea and coughing). Pathological changes and symptoms do not appear altogether, symptoms may not appear but pathological changes are likely to be present. Segmental breathing and Proprioceptive Neuromuscular Facilitation (PNF) techniques are both effective techniques in improving pulmonary functions in COPD patients.

Aim: To compare PNF and Segmental Breathing with respect to pulmonary functions to relieve dyspnoea and improve exercise capacity in COPD patients.

Materials and Methods: A comparative study conducted in Department of Physiotherapy at SGT University, Gurugram, Haryana, India, from July 2020 to June 2021. On 30 in-patient aged between 40-60 years with Forced Expiratory Volume in 1st second/Forced Vital Capacity (FEV1/FVC) <0.7, hospitalised clinically stable patients. Out of these, 15 were allocated in the segmental breathing group and another 15 participants were allocated into the respiratory PNF group through the sealed envelope. The session was of 10-15 minutes under the protocol of 18-20 repetitions of each technique in segmental breathing and respiratory PNF in either respective group. The dyspnoea was assessed by Modified Borg Scale, pulmonary functions was done with spirometry, followed by the 6-Minute Walk Test (6-MWT). The data was statistically analysed using Statistical Package for Social Sciences (SPSS) version 24.0. Paired t-test was used to compare the means of measurements within the groups. The independent t-test was used to compare the means of all the variables between the groups.

Results: Both of these techniques improved SpO_2 (change in mean from 81.27 to 86.20 and 82.13 to 90.67 days in segmental and PNF group, respectively) and relieve dyspnoea post-exertion (8.33 to 6.60 and 8.0 to 5.67 in segmental and PNF groups) within 1-week of intervention ($p < 0.01$). There was improvement seen in pulmonary functions (FEV_1 from 0.87 to 0.95 and 0.78 to 1.02 in segmental and PNF groups) and exercise tolerance 6-MWT from 149.47 to 204.80 and 151.77 to 242.20 in segmental and PNF groups) as well. And out of both, respiratory PNF is more efficient in improving pulmonary function, dyspnoea and exercise tolerance in a week ($p < 0.01$) which makes the master improvement and pulmonary rehabilitation can proceed with further advancement.

Conclusion: Segmental breathing and respiratory PNF are effective techniques for patients with COPD admitted to hospital whose modified Borg's dyspnoea score is higher even at rest and intolerant to physical exercise and peripheral capillary oxygen saturation is lower than 88%.

Keywords: Breathlessness, Chronic obstructive pulmonary dysfunction, Exercise capacity, Lung functions, Spirometry

INTRODUCTION

The COPD is a preventable and treatable disease marked by airflow limitation, destruction of lung parenchyma and other associated respiratory symptoms (e.g., dyspnoea and coughing) [1,2]. Airway irritation causes chronic inflammation which leads to structural changes like airway narrowing, parenchymal damage and reduced compliance of lungs. Loss of mucociliary escalator is also seen in this disease. Destruction of alveoli as seen in emphysema and productive cough in chronic bronchitis describes the clinical anomaly of COPD patients. Asthma has a 10 times higher risk of developing COPD [3]. Long-term exposure to irritants, age factors, occupational and outdoor-indoor pollution is the predisposing factors of COPD [4,5]. In 2019, it was found that COPD is the third leading cause of death [6]. There can be more than 5.4 million annual deaths associated with COPD by 2060.

The assessment of airflow limitation is based on spirometry, it is marked if the confirmed ratio of FEV_1/FVC value is <0.7 and FEV_1 <80% of predicted value to diagnose COPD. Post-bronchodilator spirometry is required to assess the degree of reversibility. FEV_1/FVC ratio is less likely to rise above 0.7 if initial Post-bronchodilator spirometry is less than 0.6 [7]. FEV_1/FVC between 0.65-0.75 at baseline is likely to have a diagnostic threshold because of diagnostic instability which progress with time [8]. FEV_1 decrease as a response to airflow limitation caused by inflammatory changes, leading to impaired gaseous exchange. Reducing ventilation increases the physiologic dead space which leads to CO_2 retention. As a response to retained CO_2, hypoxemia and pulmonary hypertension occur due to diffuse vasoconstriction [2]. Acute exacerbation of COPD is associated with increased attacks of dyspnoea, hypersecretion of sputum, the severity of coughing. Symptoms are related to depleting health status, increased stress and anxiety and greater sleep disturbances. All these factors can impact patients' daily livelihood and overall well-being [9].

When the tidal volume reaches approximately 75% of dynamic inspiratory capacity, a sharp increase in the intensity of exertional dyspnoea is seen [10,11]. Initially, dyspnoea occurs due to hypoventilation and blood shunting and in later stages, it involves reduced ventilation, reduces exercise tolerance, increased ventilation-perfusion mismatch, reduced lung compliance and increased end-expiratory lung volume. In most cases, the admission of patients is due to hypercapnia, unstable haemodynamics, severe dyspnoea at rest and severe limitation of physical activity and various other related symptoms. Thus, the present study was done to obtain improvement in pulmonary functions to relieve dyspnoea and hypercapnia. With fewer episodes of dyspnoea, physical activity becomes easier for the patient which builds exercise tolerance. The aim of study was to compare PNF and Segmental breathing with respect to pulmonary functions to relieve dyspnoea and improve exercise capacity in COPD patients.

MATERIALS AND METHODS

This was a comparative study conducted in Department of Physiotherapy at SGT University, Gurugram, Haryana, India. The duration of study was twelve months started in July 2020 and lasted till June 2021. All the procedures performed in this study were in accordance with the Ethical Research Committee with Ref. No. SGTU/FOP/2020/36.

Inclusion criteria: Those hospitalised patients who were aged between 40 and 60 years with FEV_1/FVC <0.7, ambulatory, cooperative, mentally alert who could follow commands were included in the study after written informed consent form.

Exclusion criteria: Patients diagnosed with history of asthma and pleural disorders, active infections, unstable heart conditions, psychiatric illnesses and cognitive deficits, neuromuscular disorders, chest wall deformities and terminal illnesses like cancer were excluded from this study [12].

Study Procedure

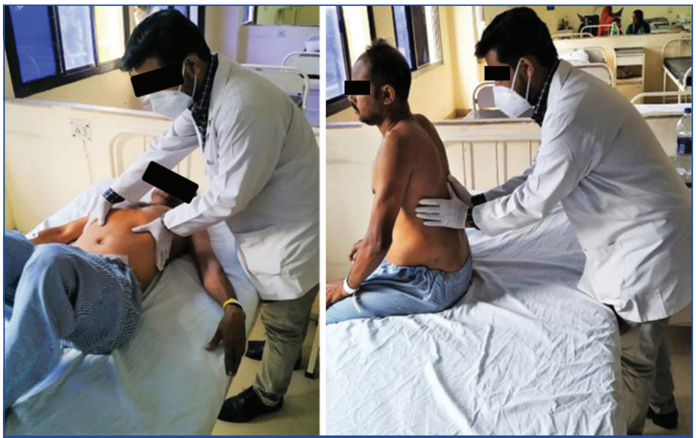
Through the sealed envelope, patients were allocated to segmental breathing group or PNF group.

The baseline measurement of dyspnoea was assessed by Modified Borg Scale, pulmonary functions was done with spirometry, followed by the 6-MWT [13,14]. All the measurements were repeated on day 7th post-intervention day. The results of the baseline tests were noted on the data collection form.

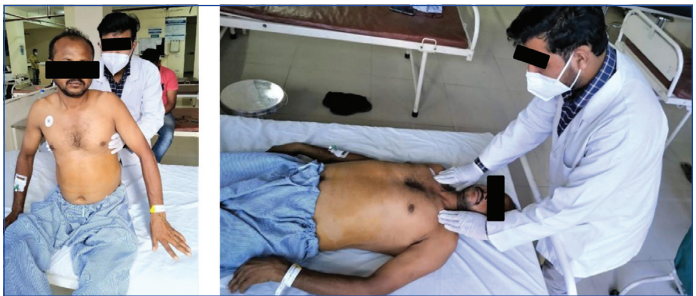
Intervention: Based on the assessment, bronchial hygiene techniques were given to clear airways and the intervention was performed. The session was of 10-15 minutes under the protocol of 18-20 repetitions of each technique in segmental breathing and respiratory PNF in either respective group.

Segmental breathing: 1) Lateral costal expansion: The hands were placed in the lateral-basal side of the chest and the patient is in the crooked lying position. The patient was instructed to exhale and a quick stretch to external intercostals was given at the end of expiration just before inspiration. The ribs were pressurised downwards and inwards to resist the initial phase of inspiration with mild resistance [Table/Fig-1]; 2) Posterior basal expansion: the patient position was in a sitting and forward-leaning position and their hips bent slightly. The hands were placed over the posterior basal segment a quick stretch was given just before inspiration and gently resist the inspiration against upward and flare movement of ribs [Table/Fig-2]; 3) Right middle lobe and lingula expansion: the hands were placed over the sides of the patient under the axilla. For sensory awareness of the segment, downward pressure to stretch external intercostal muscles and give mild resistance was applied to the movement of ribs during inhalation [Table/Fig-3]; 4) Apical Expansion: the patient was taken supine the pressure had to be applied under the clavicle by the finger pads [Table/Fig-4] [15].

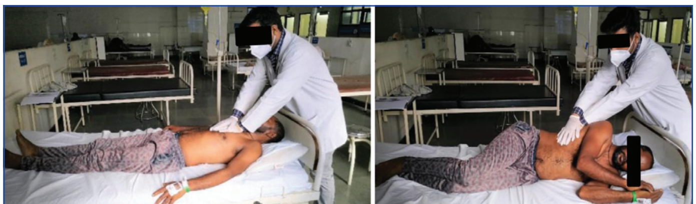
Respiratory PNF: Facilitation of inhalation was achieved through stretch reflex with repeated stretches throughout the range to increase the volume of inspiration. To guide the chest motion and strengthen the muscles a resisted inspiration was required [1]. Anterior chest wall facilitation (supine): Both hands were placed on the sternum to apply oblique downward pressure. For lower ribs, the pressure was diagonally applied in medial and caudal directions [Table/Fig-5]; 2) Lateral chest wall facilitation (side-lying): the subject was taken in a side-lying position and hands were placed diagonally on the lateral aspect of the chest wall to emphasise. Caudal and medial pressure was applied to facilitate it [Table/Fig-6]; 3) Posterior chest wall facilitation: the subject was taken in the prone lying position. Fingers were placed to follow the rib line on the posterior side of the chest. Caudal pressure was applied to emphasise [Table/Fig-7]; 4) Facilitation of diaphragm: Placing the thumb bed below the ribs anteriorly in a supine position. The thumb bed was pushed below the ribs. Stretch was applied on end-expiration and resisted during the rise of the diaphragm [Table/Fig-8] [16].



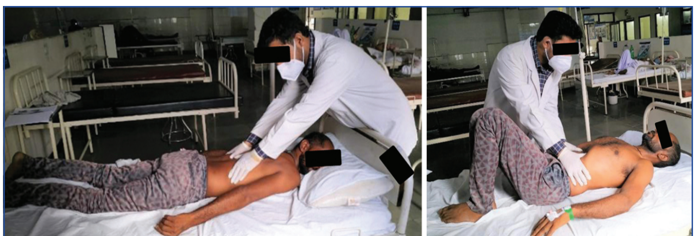
[Table/Fig-1]: Inwards applied on the ribs.
[Table/Fig-2]: A quick stretch before and downwards inspiration against upward and flare pressure movements of the ribs. (Images from left to right)



[Table/Fig-3]: Downward pressure to stretch external intercostal muscles.
[Table/Fig-4]: Apical expansion. (Images from left to right)



[Table/Fig-5]: Diagonally pressure in medial and caudal directions.
[Table/Fig-6]: Lateral chest wall facilitation (side-lying). (Images from left to right)



[Table/Fig-7]: Posterior chest wall facilitation.
[Table/Fig-8]: Facilitation of diaphragm. (Images from left to right)

STATISTICAL ANALYSIS

The data was statistically analysed using Microsoft (MS) Excel and Statistical Package for the Social Sciences (SPSS) version 24.0. Paired t-test was used to compare the means of measurements within the groups. The significance of the data is analysed at a p-value <0.05.

RESULTS

Segmental Breathing (SB) group: A significant difference was observed after 1-week of segmental breathing intervention when compared statistically [Table/Fig-9]. The pre and post-result of pulmonary functions shows significant differences FEV_1 (p, 0.001), FVC (p<0.05) and FEV_1/FVC (p=0.01), respectively. Functional capacity improve in segmental breathing group significantly (p=0.04). Therefore, a positive outcome is observed when segmental breathing was applied as an intervention. The resting dyspnoea shows decrement as mean and standard deviation [Table/Fig-9] with significance at 0.023 (p<0.05). The dyspnoea on exertion on MBS was compared between pre-and post-intervention periods with mean and standard deviation was found to have a highly significant difference, p<0.001. The mean of the resting SpO_2 and after exertion improved significantly in segmental breathing group with p-value p<0.001 and p<0.05, respectively.

Segmental breathing group				
		Day 1 (n=15)	Day 7 (n=15)	p-value[#]
Pulmonary function test	FEV_1, L	0.87±0.26	0.95±0.26	**<0.001****
	FVC, L	1.64±0.30	1.78±0.03	**0.002***
	FEV_1/FVC, %	52.18±9.37	53.73±0.09	**0.01***
Dyspnoea SpO_2 6 Minute Walk Test (6-MWT)	6-minute walk distance, m	149.47±33.706	204.80±42.85	**0.04***
	Dyspnoea, MBS, pre-6-MWT	3.97±1.59	1.60±1.23	**0.023***
	Exertion, MBS, post 6-MWT	8.33±1.28	6.60±2.65	**<0.001****
	HR, pre-6-MWT (beats/minute)	88.4±4.78	88.53±4.36	0.935[NS]
	HR, post 6-MWT (beats/minute)	104.53±7.17	99.33±18.15	0.362[NS]
	SpO_2,% pre-6-MWT	83.67±1.72	90.20±3.12	**<0.001****
	SpO_2,% post 6-MWT	81.27±1.97	86.20±3.30	**0.03***
	Systolic BP, pre-6-MWT (mm of Hg)	125.20±7.12	125.20±4.13	1.00[NS]
	Systolic BP, post-6-MWT (mm of Hg)	140.52±17.32	133.87±5.37	0.118[NS]
	Diastolic BP, pre-6-MWT (mm of Hg)	82.00±7.04	83.87±4.87	0.257[NS]
	Diastolic BP, post 6-MWT (mm of Hg)	93.07±6.01	92.27±5.61	0.647[NS]

[Table/Fig-9]: Comparison of measurements in segmental breathing group.
Paired t-test, performed among the same individual's data observed on the same day before and after completion of the 6-Minute Walking Test (6-MWT); *Significant at p<0.05; **significant at p<0.001, NS: Non significant
FEV: Forced expiratory volume; MBS: Modified borg score; SpO_2: Oxygen saturation in terms of percentage

PNF group: When the respiratory PNF group was compared for pre and post-difference [Table/Fig-10], using paired t-test, highly significant differences were observed in pulmonary functions, dyspnoea, and functional capacity and oxygen saturation before and after exertion. In this group, pre and post-exertion diastolic blood pressure was also reduced significantly observed.

Comparison between segmental breathing and PNF intervention on 7[th] day: While comparing, the mean of segmental breathing intervention group and PNF intervention group by using independent t-test non-statistical differences were observed at baseline (p>0.05). Between groups comparison after intervention on day 7 shows significant differences in pulmonary functions (FEV_1 and FVC) and post-exertion oxygen saturation (p≤0.05) [Table/Fig-11].

Proprioceptive Neuromuscular Facilitation (PNF) group				
		Day 1 (n=15)	Day 7 (n=15)	p-value[#]
Pulmonary function test	FEV_1, L	0.78±0.40	1.02±0.46**	**<0.001****
	FVC, L	1.64±0.53	1.80±0.54**	**<0.001****
	FEV_1/FVC, %	46.30±10.96	55.20±11.23**	**<0.001****
Dyspnoea SpO_2 6 Minute Walk Test (6-MWT)	Distance, m	151.77±37.27	242.20±31.57	**<0.001****
	Dyspnoea, MBS, pre-6-MWT	3.50±1.81	0.9±0.97	**<0.001****
	Dyspnoea, MBS, post 6-MWT	8.0±1.60	5.67±2.08	**<0.001****
	HR, pre-6-MWT (beats/minute)	86.93±5.09	87.33±4.78	0.287[NS]
	HR, post 6-MWT (beats/minute)	97.53±17.51	103.73±5.34	0.287[NS]
	SpO_2, % pre-6-MWT	83.93±1.75	92.73±4.23	**<0.001****
	SpO_2, % post 6-MWT	82.13±2.10	90.67±4.43	**<0.001****
	Systolic BP, pre-6-MWT (mm of Hg)	124.40 ±6.24	123.87±4.16	0.192[NS]
	Systolic BP, post-6-MWT (mm of Hg)	136.27±7.94	133.73±5.39	0.192[NS]
	Diastolic BP, pre-6-MWT (mm of Hg)	86.27±5.18	85.87±4.02	**0.022***
	Diastolic BP, post 6-MWT (mm of Hg)	96.93±5.43	93.47±3.65	**0.022***

[Table/Fig-10]: Comparison of measurements in PNF group.
Paired t-test, performed among the same individual's data observed on the same day before and after completion of the 6-Minute Walking Test (6-MWT); *Significant at p<0.05; **Significant at p<0.001, NS: Non significant
PNF: Proprioceptive neuromuscular facilitation

Between group comparison				
		SB-Group (mean±SD)	PNF-Group (mean±SD)	p-value[#]
Pulmonary function test	FEV_1, L	0.95±0.26	1.02±0.46	**0.027***
	FVC, L	1.78±0.30	1.80±0.54	**0.05***
	FEV_1/FVC, %	53.73±0.09	55.20±11.23	0.168
6 Minute Walk Test (6-MWT)	6-minute walk distance, m	204.80±42.85	242.20±31.57	**0.011**
	Dyspnoea, MBS, pre-6-MWT	1.60±1.23	0.9±0.97	0.536
	Exertion, MBS, post 6-MWT	6.60±2.65	5.67±2.08	0.229
	HR, pre-6-MWT (beatsd/minute)	88.53±4.36	87.33±4.78	0.163
	HR, post 6-MWT (beats/minute)	99.33±18.15	103.73±5.34	0.398
	SpO_2, % pre-6-MWT	90.20±3.12	92.73±4.23	0.251
	SpO_2, % post 6-MWT	86.20±3.30	90.67±4.43	**0.04***
	Systolic BP, pre-6-MWT (mm of Hg)	125.20±4.13	123.87±4.16	0.409
	Systolic BP, post-6-MWT (mm of Hg)	133.87±5.37	133.73±5.39	0.946
	Diastolic BP, pre-6-MWT (mm of Hg)	83.87±4.87	85.87±4.02	0.860
	Diastolic BP, post 6-MWT (mm of Hg)	92.27±5.61	93.47±3.65	0.460

[Table/Fig-11]: Comparison of measurements among segmental breathing and PNF groups on day 7[th] (post-intervention).
@ Independent t-test, performed among the segmental breathing intervention group and PNF intervention group observed after completion of the intervention i.e., on day 7; *Significant at p<0.05; NS: Non significant
PNF: Proprioceptive neuromuscular facilitation; Bold p-values are significant

DISCUSSION

About 30 million people are affected by COPD in India, as per a crude estimation [17]. Equal to or less than 20% of COPD deaths are in India [1]. COPD is a disease that progresses gradually and affects the airways [18]. Sonia and Gupta C discussed in their study that during exacerbation of COPD, decrease in ratio of expiratory to inspiratory time impedes the ventilator pump by reducing the efficiency of respiratory muscles and contributes to development of dyspnoea during the acute exacerbation of COPD [19]. O'Donnell DE et al., discussed in their study that the progression of COPD is underlined by reducing exercise tolerance, a gradual decrease in ventilatory capacity and increased episodes of dyspnoea [10]. A 5-day respiratory muscle training is efficient in reducing the length of hospital stay and makes the weaning easier in mechanically ventilated COPD patients. Their oxygen saturation and respiratory muscle strength also improved significantly [20].

Patients with COPD admitted due to exacerbation of symptoms, presented hemodynamic instability, respiratory infections and pyrexia in some cases [21]. It becomes very important to perform respiratory rehabilitation with caution and keep the complication in mind [22]. The complexities of every case are different which makes the response of therapy vary as per condition and time. If the oxygen saturation is not maintained on room air, then it becomes important to provide oxygen support during respiratory techniques and while performing exercise tests (i.e. 6-MWT) if needed [23].

Acute hypoxemia after the 6-MWT cause oxygen desaturation and leads to significantly increased cardiovascular baroreceptor sensitivity, which is the ability of the body to regulate blood pressure in response to changes in activity. This increase in sensitivity indicates that hypoxemia may stimulate the baroreceptor reflex pathway, resulting in enhanced cardiovascular regulation which leads to increase in pressure after exercise [24].

In the present study, both PNF and segmental breathing techniques elicit contraction and enhance the motor response of muscle fibers [25]. PNF and segmental breathing are both techniques that are found effective in improving lung volumes [26]. But the efficiency of both of these techniques might be different due to the method of performing them.

In segmental breathing, the therapist performs bilaterally whereas, with respiratory PNF, the therapist performs with both hands on one side of the patient at a time. Also, respiratory PNF facilitates the diaphragm, the primary muscle of inspiration [27]. Recruitment of the diaphragm is not done using segmental breathing. The proprioception in the diaphragm is achieved by stretching the myofibrils and creating muscle tension in the diaphragm to initiate a rise in the domes of the diaphragm. The stretch elongates the muscle by inhibiting myotatic reflex.

It was statistically significant that both segmental breathing and respiratory PNF improved pulmonary functions, dyspnoea and exercise tolerance in both the respective groups. In previous studies by Singh S et al., Liu K et al. there was a significant improvement in dyspnoea, pulmonary functions and exercise tolerance [25,28].

In this study, the SB group received segmental breathing exercises. It was found that the FEV_1 showed a mean improvement of 8% after one week. Forced vital capacity and FEV_1/FVC ratio also improved by 14% and 15.5%, respectively. Similar results were obtained by Gunjal SB et al., and Sarkar A et al., in their respective studies of segmental breathing under restrictive conditions. In their study, they found that, there was a significant improvement in the re-distribution of ventilation [29,30]. A Coronavirus Disease-2019 (COVID-19) case report involving 1-week of physiotherapy rehabilitation which involved segmental breathing found a reduction in dyspnoea, improvement of pulmonary functions and reduced pulmonary symptoms [31].

In the present study, resting dyspnoea in the segmental breathing group was alleviated by 2.37% and reduced exertional dyspnoea by 17.6%. Participants in the segmental breathing group covered 55.33% more distance after receiving the intervention. Pulmonary rehabilitation involving segmental breathing is effective in improving the 6-minute walk distance. Segmental breathing facilitates inspiration in a local segment by emphasising stretch followed by contraction against mild resistance. This encourages the local expansion of the segment, thus segmental breathing exercise throughout the chest wall improves expansion [32].

Various techniques of respiratory PNF were given to PNF group participants. In the PNF group, Force expiratory volume-$_1$ improved by 24% after the intervention. There was FVC and FEV_1/FVC ratio also showed a mean increment of 16% and 8.9%, respectively. Respiratory PNF in Parkinsonism patients showed improvement of FVC and expansion of the chest wall within 1-week [33]. Seo K, Cho M found in an experimental study found that PNF was an effective technique in their study for improving pulmonary functions in adults [34].

Participants in the PNF group experienced 26% less dyspnoea during rest and there was a 23.3% reduction of dyspnoea in modified Borg's scale score after 6-MWT. After the intervention, participants could cover a mean 6- minute walk distance of 90.43 m more than the baseline distance covered by them, on day 1. In terms of PNF being more effective for reducing dyspnoea at rest, there was a mean difference in the PNF group when dyspnoea was compared from day 1 and day 7.35. Premkumar K and Giri JUI studied the effects of PNF on 30 subjects and found that PNF showed better results in improving dyspnoea on modified Borg's scale and retraining diaphragm [35].

There was an apparent increase in lung volumes on PFT and the 6-MWT in both the respective groups. The extent of dyspnoea was reduced and a greater number of subjects could complete the test in the PNF group as compared to the segmental breathing group. After 1-week of regular intervention, the participants of the PNF group cover more distance in 6-MWT. As per this study, PNF had a better extent of improvement. Respiratory PNF improved oxygen saturation by 58.26%. PNF of respiratory muscles along with other chest physiotherapy techniques is effective in improving SpO_2, HR and respiratory rate of patients in the intensive care unit.

On day 7 of the assessment, more PNF subjects could complete the test and cover more distance, there was an observable improvement in exertional dyspnoea in the segmental breathing group. In this study, PNF subjects had better improvement in dyspnoea and exercise tolerance. The impact of this intervention can be observed on more physiological variables like ventilation, perfusion, and arterial blood gases so that more detailed mechanism can be identified for relieving dyspnea. PNF techniques can be given in different restrictive pattern of lung diseases where chest expansion can be achieved and thereby lung volume.

Limitation(s)

A particular stage of COPD was not selected and Oxygen therapy was not monitored during this study as this may vary from person to person. Secondly, the study was conducted during the COVID-19 pandemic and study sample size was not calculated. Moreover, follow-up for a longer duration was not done in the present study to examine the sustained effects of interventions.

CONCLUSION(S)

Segmental breathing and respiratory PNF are effective techniques for patients with COPD admitted to hospital whose modified Borg's dyspnoea score is higher even at rest and intolerant to physical exercise and peripheral capillary oxygen saturation is lower than 88%. Both of these techniques could improve SpO_2 at rest and relieve dyspnoea within 1-week of intervention. There was improvement seen in pulmonary functions and exercise tolerance as well. And out of both, respiratory PNF is more efficient in improving pulmonary function, dyspnoea and exercise tolerance in a week which makes the master improvement and pulmonary rehabilitation can proceed with further advancement.

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PARTICULARS OF CONTRIBUTORS:
1. Physiotherapist, Department of Physiotherapy, BLK Hospital, New Delhi, India.
2. Associate Professor, Department of Physiotherapy, SGT University, Gurugram, Haryana, India.
3. Assistant Professor, Department of Physiotherapy, SGT University, Gurugram, Haryana, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Sonia Pawaria,
Associate Professor, Department of Physiotherapy, SGT University,
Gurugram-122505, Haryana, India.
E-mail: sonupawaria@gmail.com

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