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EFFECT OF DIAPHRAGMATIC AND COSTAL MANIPULATION ON PULMONARY FUNCTION AND FUNCTIONAL CAPACITY IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE PATIENTS: RANDOMIZED CONTROLLED STUDY

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ABSTRACT

Background: Many manual procedures have long been involved in the management of chronic obstructive pulmonary disease (COPD). Few literatures evaluated the COPD responses to individual or multiple manipulative techniques, so effects are unclear and poorly understood. **Aim:** to explore ventilatory functions (VF) and functional capacity (FC) responses to diaphragmatic or costal manipulation or both in COPD patients. **Methods:** 195 male patients were randomly assigned into diaphragmatic manipulation group (group-A; n= 46), rib raising group (group-B; n= 53), both procedures group (group-C; n= 50) and control group (group-D; n= 46). Treatment regimens were applied twice weekly for 12 weeks. Forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and FC (by 6 minute walk test "6MWT") were evaluated before and after the study. **Results:** At the end of the study; FVC, FEV1 and 6MWT mean values and percentages of increases were [3.63 ± 0.56 (4.52%), 2.46 ± 0.51 (14.42 %), 416.35 ± 28.62 (3.82 %)], [3.56 ± 0.38 (5.97 %), 2.43 ± 0.48 (16.63), 415.28 ± 37.81 (3.04 5)] and [3.93±0.54 (16.92), 2.86 ± 0.5 (33.44 %), 433.03 ± 46.76 (6.9 %)] for group-A, B and C respectively ($P < 0.05$). There were also significant differences in FVC, FEV1 and 6MWT mean values between groups at the end of the study but in favor of group-C ($P< 0.05$).**Conclusions:** Diaphragmatic and costal manipulative procedures are effective therapeutic tools in improving VF and FC in COPD patients especially if applied together.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a common treatable disorder with progressive, partially reversible airflow limitation.[1,2]COPD is characterized by a gradual worsening of lung functions and health status.[3] Globally; COPD is associated with considerable morbidity and mortality proportion, it is the fifth leading cause of death in the world; with its mortality rate is expected to increase more than 30% during the next 10 years.[4]Even with recent treatment advances; COPD continues as a severely debilitating condition that is usually undiagnosed until clinical symptoms become apparent.[5] Exercise and activity intolerance are the two main characteristic features of COPD patients. Pulmonary, cardiovascular as well as skeletal muscles dysfunctions are the main underlying elements in limiting exercise capacity of COPD patients.[6]Although patients with COPD can greatly benefit from exercise training in improving functional capacity (FC) for satisfactory long periods,[7] but presence of airflow limitations and early breathlessness that may limit their FC and exercise performance[8]and may be clearly apparent during low and moderate exercise intensities or even at rest, directed researchers to seek alternative and complementary procedures that can effectively and safely benefit COPD patients. Therapeutic intervention designed to counteract COPD changes and increase chest wall compliance (as stretching of the respiratory muscles)can improve chest wall mobility, improve vital capacity and reduce dyspnea.[9]A variety of manual techniques were introduced to improve pulmonary function (PF),these techniques are targeting neuronal, lymphatic and musculoskeletal components of pulmonary system. Although variety of COPD-related manipulative procedures are not newly established treatment, but it didn't receive adequate attention in the biomedical community section.[10] Functional capacity and PF were previously used variables when evaluating the effects of manipulative treatment in variety of communities, and results were controversial. Furthermore; the chronic effects of individual manipulative technique remains unclear. Understanding such effects could lead to establishment of proper treatment protocols. Because presence of few studies reporting the influence of manipulative procedures on COPD; so little information is available about COPD patients' responses to manipulative treatment. Furthermore; and up to our knowledge and available literature - none of them investigated or compared effects of single and commutative manipulative procedures on PF and FC in COPD patients. This study was a trial to explore and compare the responses of the VF and FC to either diaphragmatic manipulation or rib rising or both procedures in patients with moderate COPD.

METERIALS & METHODS

Study design: Experimental (Randomized controlled study).

Study place: The study was conducted during May 2013 to August 2014 from Sadr Al-Abasia hospital, Egypt.

Ethics approval: This study was conducted in accordance with Helsinki Declaration principles 1975, revised in 2000 [12], was approved by the departmental council and was in compliance withthe ethics committee's principles of the Faculty of Physical Therapy, Cairo University. All patients had a history of smoking but all had stopped smoking. All patients were initially fully informed about the purpose, procedures and risks of the study and so an informed consent was obtained from each patient agreed for participation and publication of the study results.

Inclusion criteria: Age ranged from 45-65 years, with moderate COPD (50 % <Forced expiratory volume in first second "FEV_1"<80٪, Forced expiratory volume in first second per forced vital capacity FEV1/FVC <70% of predicted values) and partially reversible airway obstruction), no clinical evidence of obvious exercise-limiting cardiovascular or neuromuscular diseases. All participants were sedentary and not involved in previous rehabilitation program at least 4 months prior to the study, and had no recent infectious exacerbations for the 2 months preceding the study, with no history of psychiatry or psychological disorders. Initial medical screening was performed for each patient prior to the study.

Exclusion criteria: Patients were excluded if they had significant or unstable cardiac, musculoskeletal or psychological problems or medication that could affect or interfere with their performance or affect their safe participation, any known abdominal pathologies, history of gastroesophageal reflux of any degree, persistent hiccups within previous three months, a history of serious injury to the spine or thorax, including costal or spinal fractures or history of diaphragm surgery, bronchial asthma or restrictive lung disease or receiving long-term oxygen therapy.

Sample size: To avoid type II error, a preliminary power analysis (power (1-β error probability)) = 0.95, α = 0.05, effect size = 0.31) determined a sample size of 184 for this study to yield realistic results. In this study, included sample size was 195. To avoid bias; patient randomization was processed through two stages, first; all patients fulfilled the inclusion criteria were reported by Three volunteer physical therapists, they had no other role in the study.

Grouping: After medical counseling; patients were randomly assigned into one of the four groups through opening an opaque envelope prepared by an independent person-who had no further participation in the study-with random number generation.

Patients were randomly divided into four groups: Diaphragmatic manipulation group (group-A; n=46), Rib rising group (group-B; n=53), Diaphragmatic manipulation plus rib rising group (group-C; n=50), and Control group (group-D; n=46).

Subjects: All participants were asked to continue their drug therapies, regular diet and normal daily activities throughout the study.

Patients in group-A received diaphragmatic manipulation. Patients in group-B received rib rising manipulation. Patients in group-C received both maneuvers. Patients in group-D underwent evaluations without participation in any manipulative techniques. The study was conducted during May to August 2013 and 2014.

Outcome measures: All participants underwent an identical battery of tests. The evaluated parameters included FVC in liter, FEV1 in liter and distance covered by the patient in 6 minutes' walk test (6MWT) in meters. Evaluations were performed at the beginning and after the end of the study (after 12 weeks). The assessors were blinded to the participants' treatment assignments and groups' allocation throughout the study. All subjects' data were collected using standard laboratory procedures. Body weight was measured in light indoor clothes to the nearest 0.1 kg and patient standing height without shoes was measured to the nearest 0.1 cm using calibrated clinical weight scale and stadiometer. Body mass index (BMI) was calculated as the weight (kg) divided by the height squared (m^2).

Pulmonary Functions Test (PFT) : Ventilatory function (FVC and FEV1) were evaluated for each patient using computerized electronic spirometer (ZAN-GP12.00, made in Germany) while patients were standing. Data were expressed as a percentage of the predicted values for age, height, and sex. Full explanation of test procedures was done for each patient individually in simple terms, with emphasize on the need for maximum effort from the participant to gain the best results. All patients were previously instructed to avoid any kind of stress or heavy meals prior to the test. Inhalation of bronchodilators treatment was withheld for at least 12 hours before PF testing. Spirometry was performed before and 20 minutes after inhalation of two puffs of 200μg salbutamol. The PFT apparatus was continuously calibrated daily using a 3 liter syringe. After recording patients' data (name, age, weight, height, race and sex) in the PFT apparatus, and release of any tight clothing; the patient stands with thorax in a nearly vertical way; with the chin elevated slightly and then connected to flow sensor through a mouth piece that was held by subject's teeth and firmly enclosed by his lips, then nose clips was placed around patient's nose. The patient's then breathe normally for several cycles, then performed a slow maximal inspiration, followed by a maximum forced exhalation as much as he can. FVC and FEV1 evaluating maneuvers were repeated trice, and then the best one was selected.

Functional capacity evaluation (6MWT): The 6MWT was conducted according to a standardized protocol. [13]Patients were asked to walk at their own maximal pace from end to end of a 40 meter flat straight corridor marked every one meter by colored tape on the floor, in order to cover as much ground as possible while maintaining a steady pace without running during the allowed time. No encouragement was given, and subjects were informed each 2 minutes of the remaining time. The patients were allowed to stop, but they could start again, if possible, within the 6 minutes. Distance covered in 6 minutes was recorded in meter. For patient safety; heart rate were monitored during the 6MWT by pulse oximeter (3301; BCI International Co, Waukesha, WI, USA) as the test was to be terminate if the patient reaches 85% of their predicted maximal heart rate "HR max"(220-age). No adverse events were recorded.

Interventions (Manipulative treatment protocols):

In the study groups-A, B and C; manipulative treatments were regularly held on a frequency of two sessions per week between 9 and 11 am. Either diaphragmatic or costal manipulative procedures were repeated in form of 3 sets of 4 repetitions per each session, with 2 minutes rest between sets. All patients were directed to maintain deep and quiet breathing pattern as possible throughout the sessions, closely monitored during the treatment sessions to exclude any signs that may interfere with the continuity of the study. No adverse events or withdrawals were recorded during the study. All participants completed their prescribed treatment regimens.

1- Diaphragmatic manipulation: Diaphragmatic manipulative procedures were applied in the following sequences:

1.a- Diaphragmatic release; supine: While the patient was supine on bed; therapist's fingers' pads applied slow and steady cephalic pressure on the inferior surface of the right dome of the diaphragm below the costal arch. Pressure was maintained throughout the deep and quiet breathing cycle so that inhalation was resisted "but not restricted", a slow, gentle upward pressure was applied at the end of expiration for several cycles. Therapist's other hand was placed on the lower anterior rib cage to stabilize it. The procedure was applied on one side at a time, and then repeated on the other side.

1.b- Diaphragmatic release; sitting: The patient was seated facing a mirror, while the therapist stood behind; therapist's fingers' pads applied bilateral slow and steady cephalic pressure on the inferior surfaces of both domes of the diaphragm below the costal arches throughout the deep and quiet breathing cycle. Inhalation was resisted and exhalation was followed by slow, gentle upward pressure.

1.c- Re-Doming of the diaphragm; supine: While the patient was supine, therapist stood beside the patient at his waist level. Therapist's hands were placed antro-laterlly on either side of patient's lower costal cage, applying bilateral, simultaneous gentle resistance to thoracic motion while the patient breathe deeply and quietly. Slow, gentle upward pressure was done at the end of expiration.

2- Costal/ Rib manipulation: Costal manipulation procedures were applied in the following sequences:

2.a- Rib rising; supine-i: While the patient was supine on the bed, maintaining deep and quiet breathing pattern as possible, therapist stand beside the patient; with his hands placed under the patient's rib cage (at thoraco-lumber area). Lateral traction was applied by fingers' pads that contact posteriorly medial to the ribs' angles; lifting the rib cage by pushing down on the forearms which were used as a fulcrum. The procedure was applied on one side, and then repeated on the other side.

2.b.i- Rib Rising; Sitting: The patient was seated with his arms extended over the therapist's shoulders who stands facing him, maintaining deep and quiet breathing pattern as possible. Lateral pull was applied on the rib cage bilaterally by therapist's fingers' pads that were articulated posteriorly medial to the ribs' angles, pulling the patient forward.

2.b.ii- Rib rising-supine: The patient was supine on the bed, encouraged to inhale quietly deeply and slowly. Therapist stand beside the patient at his rib cage level, stretching the patient's intercostal muscles through applying passive, gentle raising of patient's arm in a cephalic direction with one hand while the other therapist's hand stabilizing the lower antro-lateral aspect of the rib cage on the same side. The procedure was repeated on one side, and then repeated on the other side.

3- Control group (D): Forty-six patients underwent evaluations without participation in any manipulative program, but were required to lie quietly under the same circumstances for about 30 minutes, nearly the same length of time it took to apply the manipulative techniques to the other groups.

Statistical analysis: Raw data were explored for normality using the Shapiro-Wilk statistic and measures of skewness and kurtosis. Statistical analyses were performed using SPSS software (version 16.0). Data are presented as mean ± SD. Mean changes in ventilatory functions and functional capacity within each group before and after the study were analyzed using paired t-test. Between-groups differences were analyzed using analysis of variance (ANOVA).Percent changes in evaluated variables before and after interventions were calculated in each group, Chi-Square test was used for comparison of proportions. The level of significance was set at $p < 0.05$.

RESULTS

At the pre-study evaluation; there were non-significant differences in age, body weight, height, BMI,FVC, FEV1 and 6MWT between the four groups ($p > 0.05$) (Table I). Data collected from the four groups pre and post-treatments were compared within and between groups.

Forced Vital Capacity (FVC; L): Within-group comparison revealed that there were significant increase in FVC mean values between the pre and post-study evaluations by 4.52 ± 2.25 %, 5.97 ± 2.51% and 16.92 ± 10.71% for group A, B and C respectively (P<0.05), while there was significant decrease in FVC mean value for group-D (-3.14- ± 1.27 %) between the same evaluation points ($P=1.2^{-19}$) (Table 2). Between-groups comparison revealed that there were statistically significant differences in FVC mean values ($P=1.42^{-9}$) and FVC mean percent changes ($P= 1.1^{-38}$) between groups at the post-study evaluations; but in favor of the group-C, additionally; there was non-significant difference between group-A and B in FVC mean values (P= 0.47) and mean percent changes (P= 0.21) (Table 3),

FEV1 (L): Within-group comparison revealed that there were significant increase in FVC mean values between the pre and post-study evaluations by 14.42 ± 15.74%, 16.63 ± 0.49% and 33.44 ± 4.31% for group A, B and C respectively (P<0.05), while there was significant decrease in FEV1 mean value for group-D (-1.18 ± 2.1-%) between the same evaluation points ($P= 4.85^{-4}$)(Table 2). Between-groups comparison revealed that there were statistically significant differences in FEV1 mean values ($P=4.71^{-11}$) and FEV1 mean percent changes ($P=2.04^{-49}$) between groups at the post-study evaluations; but in favor of the group-C, furthermore; there was non-significant difference between group-A and B in FEV1 mean values (P= 0.75) and FEV1 mean percent changes (P= 0.17) (Table 3).

Table1: The demographic characteristics of participants

Character	Diaphragmatic Manipulation **(Group-A)**	Rib Rising **(Group-B)**	Both Procedures **(Group-C)**	Control group **(Group-D)**	**F-Value**	**P-Value**
Age (year)	52.52 ± 5.51	53.94± 5.57	53.24 ± 5.71	54.64 ± 5.8	1.21	0.31
Weight (Kg)	70.3 ± 3.02	69.59± 2.89	69.3 ± 3.19	68.93 ± 2.91	0.09	0.17
Height(meter)	1.69 ± 0.72	1.68± 0.73	1.69 ± 0.05	1.70 ± 0.63	0.81	0.49
BMI (kg/m^2)	24.85 ± 2.47	24.25 ± 2.341	24.25 ± 1.54	23.84 ± 1.96	2.12	0.1
FVC-Pre (Liter)	3.48± 0.55	3.36 ± 0.37	3.38 ± 0.47	3.36 ± 0.43	0.7	0.56
FEV1-Pre (Liter)	2.17 ± 0.44	2.09 ± 0.42	2.15 ± 0.38	2.15± 0.38	0.42	0.74
6MWT-Pre(meter)	401.11 ± 28.4	403.13 ± 37.95	405.06 ±43.71	402.8 ± 39.62	0.088	0.97
FVC/FEV1-Pre(%)	65.85 ± 10.21	62.13 ± 10.81	63.53 ± 6.6	64.12 ± 7.97	3.84	1.0

Level of significance at P<0.05.⋆ = significant

Table 2: Within groups comparison of FVC, FEV_1, MVV and 6MWT mean value for the four groups (pre-posttest)

Character		Diaphragmatic Manipulation **(Group-A)**	Rib Rising **(Group-B)**	Both Procedures **(Group-C)**	Control group **(Group-D)**
FVC (Liter**)**	T-Value	-15-	-17.84-	-12.03-	15.7
	P-Value	4.02^{-19}⋆	8.01^{-24}⋆	3.09^{-16}⋆	1.2^{-19}⋆
FEV1 (Liter**)**	T-Value	-5.64-	-38-	-36.65-	-3.77-
	P-Value	1.06^{-6}⋆	1.31^{-39}⋆	2.84^{-37}⋆	4.85^{-4}⋆
6MWT (meter)	T-Value	-60.72-	-54.54-	-64.53-	18.33
	P-Value	8^{-45}⋆	1.43^{-47}⋆	4.61^{-49}⋆	3.23^{-22}⋆

Level of significance at P<0.05.⋆ = significant

Table 3: Post-hoc multiple comparisons mean percent changes (between groups) (P value).

Variable	**Group**	**Group-A**		**Group-B**		**Group-C**	
		Means	**%**	**Means**	**%**	**Means**	**%**
FVC, (FVC %) (P value)	Group-B	0.47	0.21				4.703^{-40}
	Group-C	0.002	7.43^{-21}	1^{-4}	2.88^{-18}		
	Group-D	1.87^{-4}	1.39^{-9}	0.001	3.24^{-13}	4.37^{-11}	
FEV1, (FEV1 %) (P value)	Group-B	0.75	0.17				2.54^{-51}
	Group-C	4.99^{-5}	7.88^{-24}	6.98^{-6}	5.88^{-21}		
	Group-D	0.001	4.43^{-17}	0.002	6.71^{-22}	1.57^{-12}	
6MWT, (6MWT %) (P Value)	Group-B	0.89	1.05^{-18}				3.6^{-164}
	Group-C	0.04	3.23^{-92}	0.02	1.14^{-111}		
	Group-D	0.04	2.1^{-122}	0.04	3.58^{-111}	3.3^{-5}	

Level of significance at P<0.05.

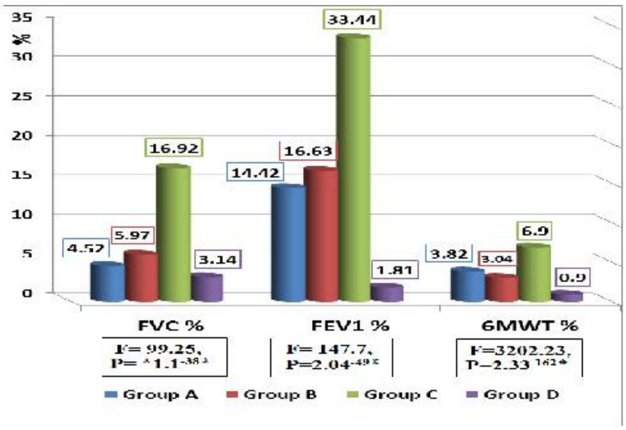

Fig 1: Percentages of change in FVC, FEV_1, and 6MWT in all groups.

6MWT (m): Within-group comparison revealed that there were significant increase in 6MWT mean values between the pre and post-study evaluations by 3.82 ± 0.49%, -3.04± 0.52- % and -6.90 ± 0.08- % for group A, B and C respectively (P<0.05), while there was significant decrease in group-D by (0.9 ± 0.3 %) between the same evaluation points (P= 3.23^{-22}) (Table 2). Between-groups comparison revealed that there were statistically significant differences in 6MWT mean values (P=0.001) and 6MWT mean percent changes (P=2.33^{-162}) between groups at the post-study evaluations; but in favor of the group-C, furthermore; there was non-significant difference between group-A and B in 6MWT mean values (P= 0.892) and 6MWT mean percent changes (P= 0.08) (Table 3, Figure 1).

DISCUSSION

The purpose of this study was to investigate the effect of 12-weekdiaphragmatic, rib manipulation therapy or both procedures together on VF and FC in patients with moderate COPD. The main outcome of this study was that although COPD patient can significantly benefit from either diaphragm or rib manipulative treatment, but combined application of both procedures yielded more beneficial increase in VF and FC in COPD patients. Results also clarified that there were non-significant differences in FVC, FEV1 and 6MWT mean values between group-A and B at the end of the study.

Impaired exercise capacity (EC) and reduced health related quality of life are common features of COPD patients.[14] Assessment of FC has gained importance in understanding the impact of disease and establishment of COPD-management procedures. The development of valid and reliable measures of EC in COPD patients reflects the growing perception of the importance of monitoring and maintaining EC in COPD patients.[15] Proper ventilation and functional performance of the pulmonary system depends mainly on -and is tightly linked to- the ability of respiratory muscles to respond adequately to a given metabolic stress.[16] Many literatures handled the relationship between good breathing pattern and health maintenance.[17,18, 19, 20, 21] The diaphragm plays an important role in maintaining efficient quiet breathing pattern,[21] with the normal diaphragmatic contribution to tidal volume is about two-thirds and three-fourths during erect and supine positions.[23]

COPD manifests itself in reduced diaphragm mobility, as investigated by Yamaguti et al, who objectively evaluated diaphragm displacement in COPD patients using ultrasound and found significant reduction in diaphragm mobility compared with normal healthy subjects.[24] Diaphragm and internal intercostal muscles abnormalities and hypertonicity are commonly observed musculoskeletal changes in COPD patients,[25] resulting in disturbed and dysfunctional breathing pattern.[17] Pathologically increased workload in COPD results in dysfunction of the diaphragm and rib cage.[10,17] Flattening of diaphragm seen in COPD can decrease the movement of the lower ribs and reduce the efficiency of respiration, thereby reducing ventilation of the lungs; finally producing undesirable health consequences.[26]

Manipulative therapy of the diaphragm increases its excursion and hence improves breathing mechanics,[22] facilitates bronchial tree lymphatic flow and so reduces airways congestion[27] and beneficially reduce the hypertonicity of the diaphragm shown in COPD by stretching it,[28] so increasing its efficacy during inspiration as well as in expiration.[29] Manipulative treatment is effective in health as well as in disease. Manipulative treatment significantly improves FVC and FEV1 in normal individuals.[30] Manipulative techniques for COPD can increase thoracic cage and ribs mobility, mobilize thoracic spine [31] and so can improve PF; not only in adults but also in pediatrics[32] and postoperative patients. [33] Influences of manipulative procedures were further evaluated in other pathological cases, manipulative treatments significantly improve respiratory parameters in patients with idiopathic Parkinson's syndrome.[34]

Studies evaluating the effect of manipulative treatment on PF in COPD patients have produced variable results. There were so many published studies in the field of COPD management; however few studies reported manipulative treatment as an important and useful modality for COPD patients.[35] Majority of available studies focuses mainly on measuring acute effects of applied treatment on health [36] or disease.[37,38,39] Majority of published studies on the field of utilizing manipulative procedures in COPD treatment focused on evaluating acute or immediate effects of either single or multiple manipulative procedures and results of these studies are confusing. Reported acute effects floated from no change on PF,[36] to symptomatic improvement with mild worsening of many lung function parameters,[37] to positive noticeable effect in other studies.[38] These conflicting results may be attributed to study design, different treatment protocols, small sample size, and over-manipulation. Unfortunately, the established benefits of manipulative treatment procedures are relatively marginal and primarily affect symptomatic aspects.[40]

In a small sample and short duration study; Miller reported that manipulative procedures improved FC in COPD patients, manifested in increased walking distance, reducing dyspnea after treatment. On the other hand; there was a worsening of patients' residual volume and total lung capacity.[41] COPD patients treated with manipulative procedures can gain significant improvement in forced expiratory flow at 25%-50% of vital capacity and at the mid-expiratory phase. Worsening of residual volume and total lung capacity can be attributed to over-manipulation, utilization of "thoracic lymphatic pump technique" that resulted in rapid lungs inflation while COPD patients were not able to fully exhale because of the underlying pathology.[38] COPD patients' responses to sequential manipulation sessions of four weeks interval were evaluated by Noll et al., and results revealed an easing of symptoms, worsened PF and increased residual volume. [39] COPD patients benefit greatly from thoracic spine and chest cage manipulation through reduction in COPD symptoms and increases oxygen saturation.[42] Beneficial effects of manipulative therapy in COPD can be also explained on the basis of improvement of primary and accessory respiratory muscles' fibers, that in turn can be reflected on better functioning small and medium airways.[43]

Few longer duration studies evaluated the effects of manipulative treatment and reported beneficial effects.[44, 45] One can conclude that the length of the study is an important factor that affects treatment outcomes. Sufficient time course of manipulative treatment was correlated with significant improvement in arterial blood gases and PF in COPD cases.[45] Adding to that; the efficacy of manipulative treatment may be enhanced by using manipulative procedures in combination, where one procedure works synergistically with another to achieve overall therapeutic effect.[10] The principal limitation of a multi-technique manipulative treatment is that the contribution of each technique to the final result is unknown; [37] furthermore; none of these studies clarified the long-term impact of manipulative treatment on COPD patients. [40]

CONCLUSIONS

Functional outcomes of COPD patients may be limited by pulmonary, musculoskeletal constraints and low functional capacity. Diaphragmatic or costal manipulation procedures yielded significant benefits on both pulmonary function and functional capacity in patients with moderate COPD. Furthermore; results reported better responses of pulmonary function and functional capacity to combined application of both procedures.

Limitations: Although chronic effects of manipulative procedures on COPD were evaluated, but still there are a lack in our knowledge regarding to how extent these effects will persist. Male gender was another limiting factor. Further studies are needed to cover areas of deficiencies in this study. Future studies should include both genders and to be conducted on a long follow-up basis.

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Conflict of Interest: Nil

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