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Assessment function of chest ultrasound in diaphragm evaluation among COPD before and after pulmonary rehabilitation programme at Zagazig University

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Abstract

Background *Chronic Obstructive Pulmonary Disease (COPD) is currently the world's fourth leading cause of death. Pulmonary rehabilitation is a well-recognized method in the treatment of persons with COPD aimed at improving the physical and psychosocial conditions of patients. The aim was to assess the function chest ultrasound in diaphragm evaluation among COPD before and after pulmonary rehabilitation programme.* ***Methods****This study was was cohort study that conducted on 90 stable COPD patients underwent pulmonary rehabilitation programs were included. All participants were subjected to the followings: Spirometric pulmonary function (Before and after rehabilitation). Six minute walking test (Before and after rehabilitation)˙ Assessment of diaphragmatic excursion by ultrasound (Before and after rehabilitation). The patients were lying in the semi recumbent position, with the head of the bed elevated at an angle between 30° and 45°. With the probe fixed on the chest wall during respiration, the ultrasound beam was directed to the hemi diaphragmatic dome at an angle of not less than 70°. During inspiration, the normal diaphragm contracts and moves caudally toward the transducer; this is recorded as an upward motion of the M-mode tracing. The amplitude of excursion was measured on the vertical axis of the tracing from the baseline to the point maximum height of inspiration on the graph*.*. Assessment of diaphragmatic thickness (Before and after rehabilitation). Patients were undergone rehabilitation program for 12 weeks. Successful or failed rehabilitation: Based on SGRQ the patients classified it to failed and successful groups. The latter was defined as an improvement in quality of life as measured by a decrease of 4 points or more on the SGRQ.* ***Results*** *prevalence of successful pulmonary rehabilitation was 71.1%.Pulmonary Rehabilitation reported significant improvement of respiratory function as well as physical and general quality of life, P < 0.001 for all parameters, hence, considering the dyspnea scale, it was significantly improved after Pulmonary Rehabilitation by 35%. SGRQ was significantly improved by 10%, in addition, regarding the spirometric parameters of patients, it*

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showed significant improvement by 2%. Arterial oxygen saturation improved by 2%. Finally, 6MWD showed significant improvement by 9%. there were significant improvement in diaphragmatic performance (DE and DT) after pulmonary rehabilitation program by 6% and 15% respectively ***Conclusions****Diaphragmatic ultrasound examination of stable COPD patients undergoing pulmonary rehabilitation is accurate and reliable method for assessing diaphragmatic function and improvement.The early Pulmonary Rehabilitation program in stable COPD patients of mild and moderate degrees of severity gives the better outcome than those of severe degree of the disease.*

Key words: *Assessment- chest ultrasound- diaphragm evaluation- COPD- pulmonary rehabilitation programme*

I. Introduction:

COPD is currently the world's fourth leading cause of death but is expected to be the third leading cause of death by 2020. Globally, the burden of COPD is projected to increase in the coming decades due to continued exposure to COPD risk factors and population ageing[(1)].

Inspiratory muscle weakness is of great clinical significance in patients with COPD. The function of the diaphragm; the most critical respiratory muscle, which deteriorates in subjects with COPD mainly due to the dramatic increase of the lung volume known as pulmonary hyperinflation, which shortens and flattens the diaphragm and affects its function negatively [(2)].

Both pulmonary hyperinflation and increased airway resistance increase the work of breathing, which is mainly dependent on inspiratory muscles, so that respiratory muscles need to perform heavy duty under very adverse conditions[(3)].

Muscle tiredness is now considered to be a major contributor to COPD intolerance. Patients with COPD develop dyspnea as their lung function decreases, which can be distressing enough to discourage them from taking more physical exercise.When their physical activity rates drops, their ambulatory muscles undergo structural and biological deconditioning[(4)].

The effects of deconditioning are particularly evident in lower limb muscles, many of the structural and biochemical changes found in COPD are identical to those induced by disuse (fibers decrease and the proportion of fibers of type II increases) and are reversible with exercise[(5)].

Pulmonary rehabilitation is a well-recognized method in the treatment of persons with COPD aimed at improving the physical and psychosocial conditions of patients by delivering tailor-made treatments, including instruction, education and behavioral changes delivered by an interdisciplinary team of healthcare professionals.There is strong evidence that training decreases ventilation requirements and reduces the degree of dynamic lung hyperinflation that results in an improved arterial oxygen content, thus increasing the availability of systemic muscle oxygen[(6)].

It has been shown in previous studies that a combination of improved mechanical efficiency and improved respiratory and skeletal muscle strength can assess desensitization to dyspnea and thus reduce dynamic hyperinflation.Such physiological advantages extend to all patients with COPD, regardless of the severity of the condition, and are associated with increased exercise tolerance, functional ability and quality of life, thereby decreasing breathlessness and hospital admissions and increasing rehabilitation after exacerbation[7].

Nevertheless, the reactions to pulmonary rehabilitation can vary considerably between individuals.Uponrecovery, several studies could not detect significant changes in forced expiratory volume in the first second, forced vital capacity and FEV1/FVC values.A wide range of outcome measures for assessing clinically relevant outcomes after recovery have been identified [8].

It was hypothesized, therefore, that US variability in diaphragm mobility and thickness before and after a pulmonary rehabilitation program could represent good indicators of the impact of a successful program on COPD patients, and that these improvements could correlate with positive post-rehabilitation outcome measures[9].

The purpose of this work is to assess the function of chest ultrasound in diaphragm evaluation among COPD before and after pulmonary rehabilitation programme.

II. Patients & Methods

a) Study Design: A Cohort study

b) The Study Setting:

This study was carried out from February 2019 to November 2019 in the Department of Chest, Zagazig University Hospitals. It was accepted by Instilutional Review Board-Zagazig University. All participants obtained written, informed consent.

c) Patients:

Ninety stable COPD patients, aged 45-75, completed pulmonary rehabilitation services at Zagazig University Hospitals Chest Department's Pulmonary Rehabilitation Center.

<u>Criteria for inclusion:</u>

I. COPD was diagnosed under GOLD (2019) based on:

II. * risk factor involvement eg. smoking.

Symptoms that suggest COPD, eg.Dyspnea, cough and expectoration increasingly recurrent.

Pulmonary function tests: FEV1/FVC post bronchodilator < 0.7

II.Co-operative COPD Patients

III.4 weeks before beginning pulmonary rehabilitation, free from exacerbations.

Methods

1. medical history taking and clinical examination.

2. Degree of breathlessness related to activities was assessed by modified medical research council (mMRC) score[10]

3. Plain chest X-ray postero-anterior view.

4. Spirometric pulmonary function (Before and after rehabilitation). Classification of severity of air flow obstruction was in accordance with GOLD (2019) [11]:

5. Six minute walking test (Before and after rehabilitation) [12]

6. Assessment of diaphragmatic excursion by ultrasound (Before and after rehabilitation). The patients were lying in the semi recumbent position, with the head of the bed elevated at an angle between 30° and 45°. Diaphragmatic movement was measured using a 3.5-MHz US probe placed over one of the lower intercostal spaces in the right anterior axillary line with a SonoScape ultrasound machine (SonoScape SSI-4000, SonoScape Medical Corp., Guangdong, China; EC REP SonoScapeEurop S.R.L, Rome, Italy).

With the probe fixed on the chest wall during respiration, the ultrasound beam was directed to the hemi diaphragmatic dome at an angle of not less than 70°. During inspiration, the normal diaphragm contracts and moves caudally toward the transducer; this is recorded as an upward motion of the M-mode tracing. The amplitude of excursion was measured on the vertical axis of the tracing from the baseline to the point maximum height of inspiration on the graph**.** Six measurements were recorded and averaged. [9,13]

7. Assessment of diaphragmatic thickness (Before and after rehabilitation)[9]. It is measured with a high frequency linear probe (10 MHz). The diaphragm was visualized by placing the transducer perpendicular to the chest wall, in the eighth or ninth intercostal space, between the anterior axillary and the mid axillary lines, to observe the zone of apposition of the muscle 0.5 to 2 cm below the costophrenic sinus.It is measured with a high frequency linear probe (10 MHz). The diaphragm was visualized by placing the transducer perpendicular to the chest wall, in the eighth or ninth intercostal space, between the anterior axillary and the mid axillary lines, to observe the zone of apposition of the muscle 0.5 to 2 cm below the costophrenic sinus. The patient was then instructed to perform breathing to total lung capacity (TLC) and then to exhale to residual volume (RV). Several images of the diaphragm were captured and stored, including at least three at the point of maximum thickening at TLC and at least three at minimum thickening at RV. On each frozen B-mode image, the diaphragm thickness was measured from the middle of the pleural line to the middle of the peritoneal line. Then, the tdi % (trans diaphragmatic thickness fraction) was calculated**.**

$$\text{tdi \%} = \frac{\text{Thickness at end of inspiration} - \text{Thickness at end of expiration}}{\text{Thickness at end of expiration}} \times 100$$

8. Patients were undergone rehabilitation program for 12 weeks in the form of:

A. Patient health education[11]

- Basic information about COPD and value of smoking cessation).

- General approach to therapy and specific aspects of medical treatment.
- Self-management skills.
- Strategies to help minimize dyspnea.
- Advice about when to seek help, decision making during exacerbations.
- Value of physical exercise in COPD.

B. Exercise training programs[14]

Various modes of training for both upper and lower limbs. It includes endurance (aerobic), strengthing (resistance) exercises and breathing retraining technique according to(**Spruit et al., [(15)].**

#Endurance training (cycle based vs. walking)

-Cycle based using ergometer

-Walking based using treadmill

-Arm exercise using arm wheel

■Continuous endurance training

The framework recommended by American college of sports medicine (ACSMs) guidelines for exercise testing and prescription on frequency, intensity, time and type (FITT). Frequency: 3 times/week. Intensity targets were 60-70% of maximum heart rate; HR max. (HR max= 220 - age), then it was increased gradually by 5-10% to reach 80-90% according to patients, ability tootle rate exercise.

Time of exercise was 10-15 minutes in 1st 3-4 sessions,then↑ progressively to 30-40 min. Type of exercise is continuous exercise

-We monitored O2 saturation, heart rate, Borg dyspnea score and limb fatigue during every exercise training session.

Modified borg scale[16] used to assess the degree of breathlessness. This is a scale to rate the difficulty of breathing. It starts at number 0 where breathing is causing no difficulty at all and progresses through to 10 where breathing difficulty is maximal. End of exercise if Modified Borg scale >4-6 or Peak heart rate was reached

■Interval endurance training: Alternative to continuous endurance training for patients who have difficulty in achieving their target intensity or duration because of dyspnea or fatigue. It is a modification of endurance training in which high intensity exercise is regularly interspersed with periods of rest.

Frequency is 3times/week. Intensity targets were 80-100% of maximum heart rate in the first 3-4 sessions, then it was increased gradually by 5-10% to reach 150% according to patients, ability to tolerate exercise.

Type of exercise was interrupted with equal periods of rest and periods of exercise. Time is 30 second–180 second exercise with equal periods of rest.

-Total time of exercise was 15-20 minutes in 1st 3-4 sessions, then ↑ progressively to 45-60 min (including resting time).

-Monitoring and end of exercise same as continuous endurance training.

Strength training (resistance training): Free weights, Thera-Band and Ball exercise for both upper limb and lower limb according to American college of sports medicine [17]in the form of 2-4 sets of 6-12 repetitions should be under taken on 2-3 days/ week.End of exercise: Modified Borg scale >4-6 or muscle fatigue

#Breathing retraining (breathing exercises) [18]

It included Pursed-lip breathing in which patient inhales through the nose with mouth closed, exhale through mouth lips pursed tightly. Exhalation was twice as long as inhalation. Also, diaphragmatic breathing in which patient inhales slowly through nose with abdomen expands outwards, exhale slowly through pursed lip while drawing abdomen inward.

Successful or failed rehabilitation: Based on SGRQ the patients classified it to failed and successful groups. The latter was defined as an improvement in quality of life as measured by a decrease of 4 points or more on the SGRQ[19]

Statistical analysis

Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0) (Statistical Package for the Social Sciences) software for analysis. According to the type of data qualitative represent as number and percentage, quantitative continues group represent by mean ± SD, the following tests were used to test differences for significance; difference and association of qualitative variable by Chi square test (X^2). Differences between quantitative independent groups by t test, correlation by Pearson's correlation or Spearman's. Paired t-test used to compare between one groups before and after treatment.Independent t-test: used to compare between two independent groups Person Receiver operating characteristic (ROC) curve; was used to identify optimal cut-off values of DE and DT changes with maximum sensitivity and specificity for prediction of successful pulmonary rehabilitation, Area under Curve (AUC) was also calculated, > 0.60-0.70 considered acceptable. All statistical tests were two sided, *P* considered significant if < 0.05.

III. Results:

A cross-sectional retrospective study conducted on 90 patients with stable COPD who met the comprehensive pulmonary rehabilitation program requirements and after 3 months of continuous rehabilitation, all patients who completed the course were assessed to determine their diaphragmatic output (Diaphragmatic Excursion and Diaphragmatic Thickness) in conjunction with rehabilitation.

A-Description of the studied patients

Table (1): Demography of studied patients

Factors	Total (n = 90)		
Age(years)	mean	±	SD
	61.9	4.705	
	median	(Min-Max)	
	63	49-70	
Sex	N	%	
Female	16	17.78	
Male	74	82.22	
Smoking status	N	%	
Smoker	69	76.67	
EX-smoker	21	23.33	
BMI(Kg/m^2)	mean	±	SD
	23.844	3.298	
	median	(Min-Max)	
	24	20-29	

N: number, SD: stander deviation, Min: minimum, Max: maximum, Continuous data represented as mean and SD and categorical data as number and (%).

- The mean age of the studied patients was 62 years (ranged from 49 up to 70 years) , 82.22% were males and 76.67%were smokers with mean BMI about 24 kg/m^2.

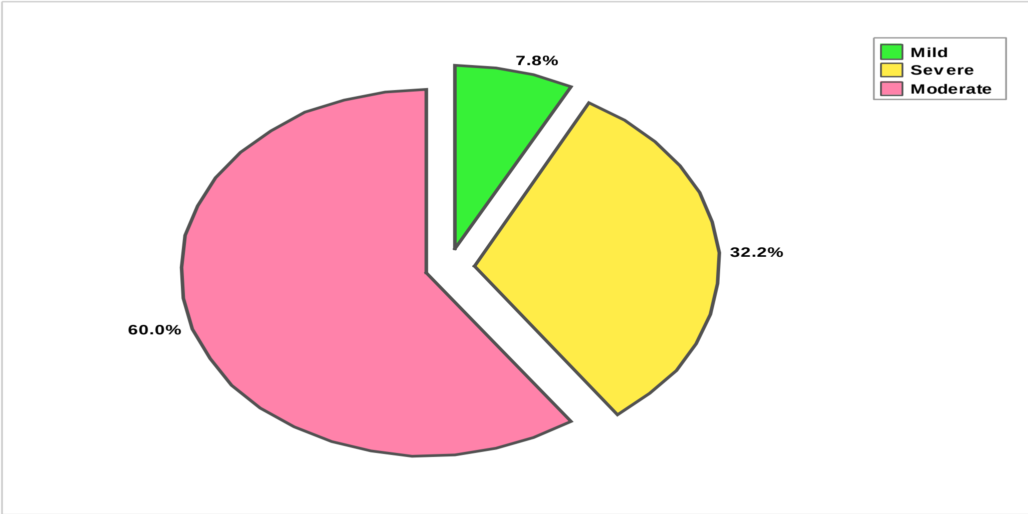

Figure (1): Classification of studied COPD patients according to severity of disease.

- Regarding COPD severity grades of studied population 7.8% were mild ,32.2% were moderate and 60% were severe.

B-<u>Analysis of Pulmonary Rehabilitation program effect on pulmonary performance</u>

Based on SGRQ changes the patients were classified into failed and successful Pulmonary R groups.

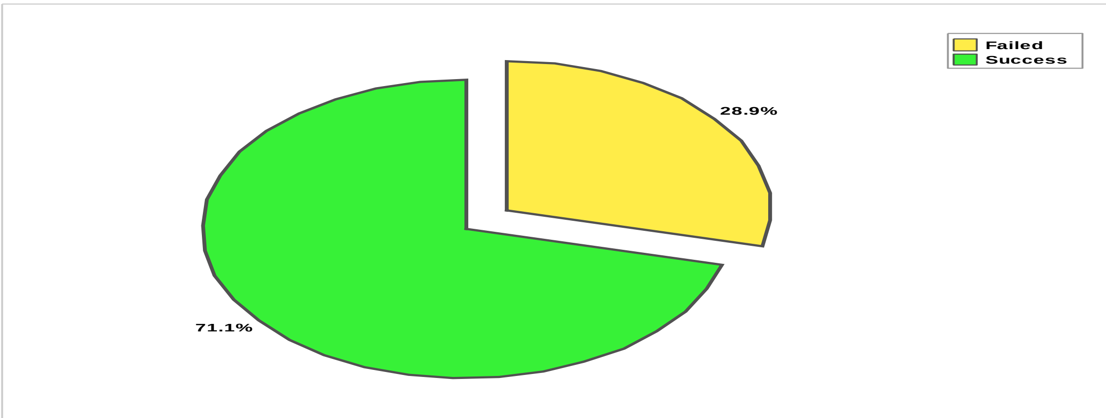

Figure (2): Prevalence of successful Pulmonary Rehabilitation

The prevalence of successful pulmonary rehabilitation in the studied patients reached to 71.1%.

Table (2): The frequency of successful Pulmonary Rehabilitation in relation to COPD severity

Outcome	Mild (n=7)	Moderate (n=54)	Severe (n=29)	P
Failed	0 (0%)	13 (24.07%)	13 (44.83%)	0.03#
Successful	7 (100%)	41 (75.93%)	16 (55.17%)	

N: number, categorical data represented as number and (%), #: chi square test, P considered significant if < 0.05.

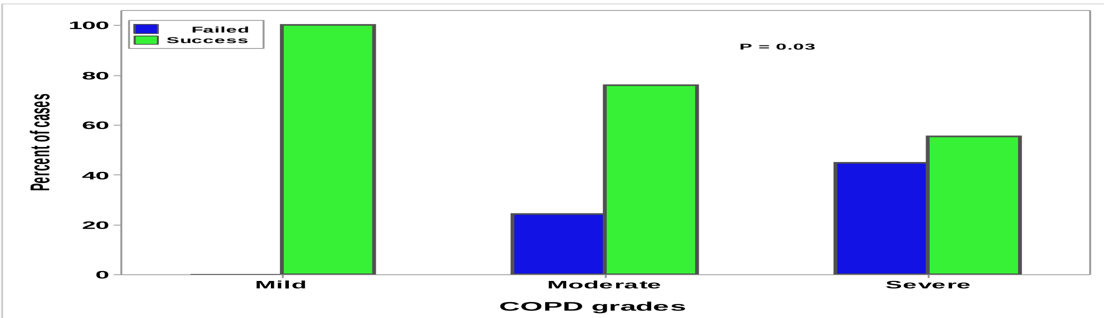

Figure (3): Successful Pulmonary Rehabilitation in correlation with COPD severity.

The frequency of successful Pulmonary Rehabilitation was significantly higher in mild and moderate groups of COPD, while failed outcome was significantly associated with severe degree of COPD, P = 0.03.

Table (3): Diaphragmatic evaluation by US after pulmonary rehabilitation program

Factors	Total (n = 90)				
	mean	SD	median	Min	Max
DE (Cm)	3.15	0.81	2.00	2.95	4.88
DT (Cm)	1.17	0.27	0.79	1.20	1.71

DE: diaphragmatic excursion, DT: diaphragmatic thickness, N: number, SD: stander deviation, Min: minimum, Max: maximum, Continues data represented as mean and SD

After Pulmonary Rehabilitation program; the mean DE was 3.15 cm, while DT was 1.17 cm.

Pulmonary Rehabilitation reported significant improvement of respiratory function as well as physical and general quality of life, P < 0.001 for all parameters, hence, considering the dyspnea scale, it was significantly improved after Pulmonary Rehabilitation by 35%. SGRQ was significantly improved by 10%, in addition, regarding the spirometric parameters of patients, it showed significant improvement by 2%. Arterial oxygen saturation(sao_{2}) improved by 2%. Finally, 6MWD showed significant improvement by 9%.

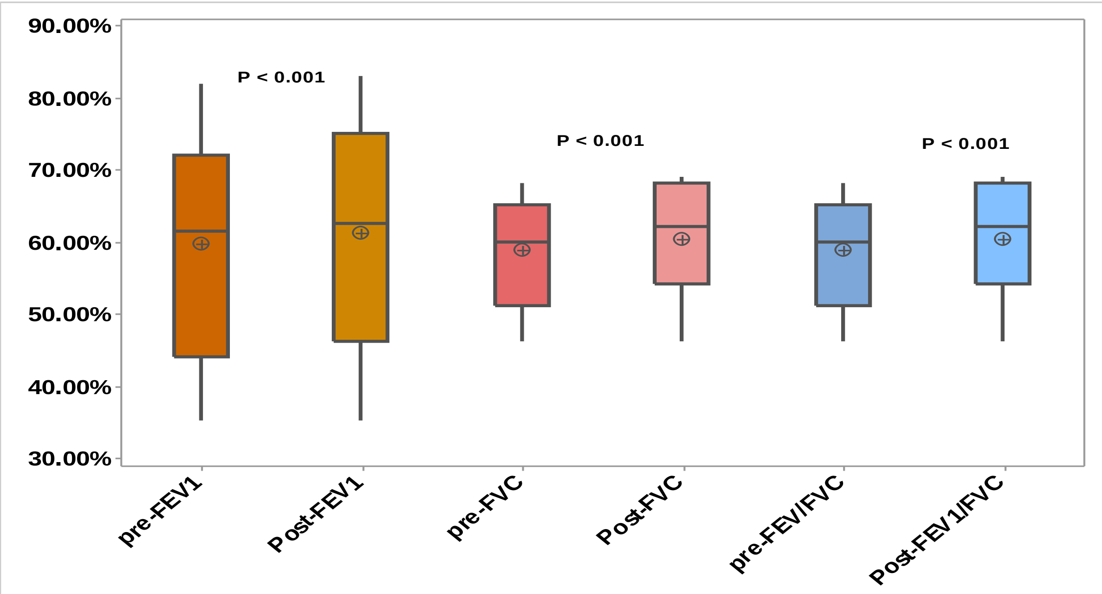

Figure (4): Impact of Pulmonary Rehabilitation on spirometric readings

A significant improvement noticed regarding all spirometric values, P < 0.001.

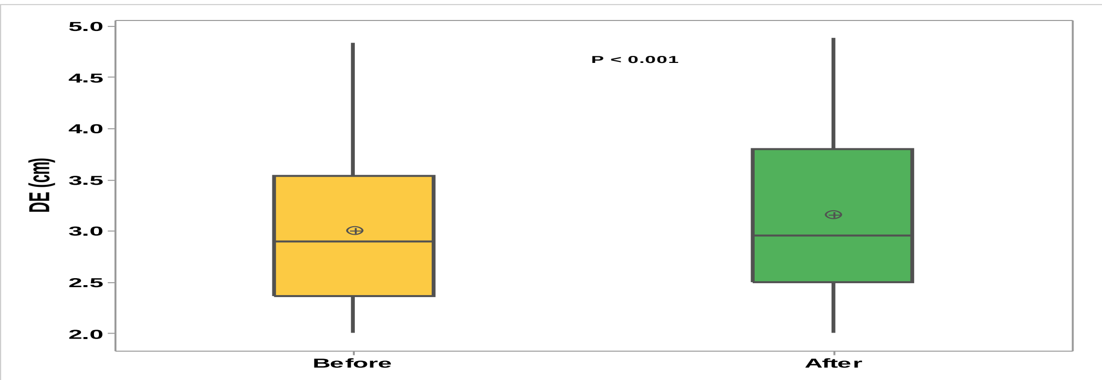

Figure (5): DE before and after Pulmonary Rehabilitation program.

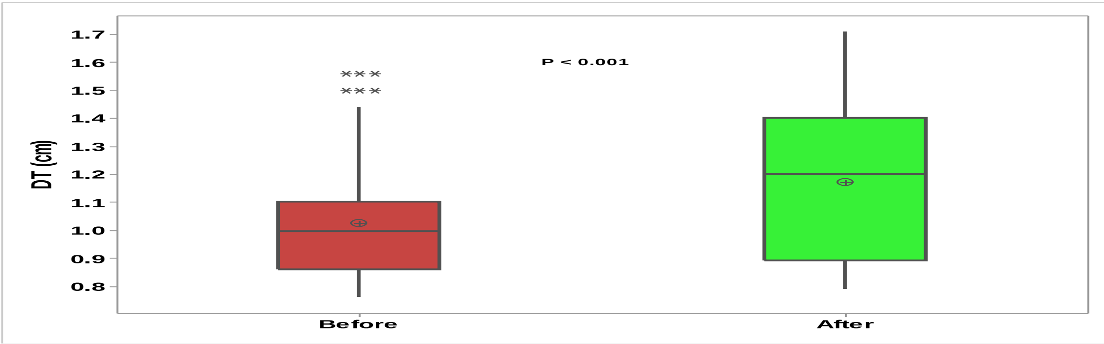

Figure (6): DT before and after Pulmonary Rehabilitation program.

Therewere significant improvement in diaphragmatic performance (DE and DT) after pulmonary rehabilitation program by 6% and 15% respectively, P < 0.001 for both.

Table (4): Dyspnea scale, 6MWD, spirometric and diaphragmatic parameters in failed and successful pulmonary rehabilitation groups

Variable	Failed (n=26)		Successful (n=64)		P[$]
	(mean± SD)		(mean± SD)		
mMRC	1.42	0.50	1	0.24	< 0.001
FEV1%	47%	12%	67%	13%	< 0.001
FVC %	52%	6%	64%	6%	< 0.001
FEV/FVC	52%	6%	64%	6%	< 0.001
6MWD (m)	368	28.6	478.3	58.4	< 0.001
DE (cm)	2.45	0.45	3.44	0.74	< 0.001
DT (cm)	0.95	0.16	1.26	0.25	< 0.001

N: number, SD: stander deviation, Continues data represented as mean and SD, $: Independent t-test, P considered significant if < 0.05.

mMRC scale, spirometric and diaphragmatic parameters were significantly higher in successful rehabilitation group than in failed group, P < 0.001 for all.

Table (5): Changes in SGRQ, CAT, BODE index and mMRC score in failed and successful pulmonary rehabilitation groups

Variable	Failed (n=26)		Successful (n=64)		$P^{\$}$
	(mean± SD)		(mean± SD)		
mMRC	-31%	10%	-38%	12%	< 0.001
BODE index	-46%	10%	-34%	24%	< 0.001
CAT score	-1%	2%	-13%	6%	< 0.001
Total-SGRQ	0%	0%	-13%	5%	< 0.001

N: number, SD: stander deviation, Continues data represented as mean and SD, $: Independent t-test, P considered significant if < 0.05.

The percentage of changes in dyspnea scale and other evaluating scores of COPD status was significantly lower in successful rehabilitation group than in failed group, P < 0.001 for all.

Table (6): Correlation between changes in diaphragmatic parameters and changes in spirometric reading

Variable	DE change		DT change	
	R	P^*	r	P^*
FEV1%	0.19	0.07	0.44	< 0.001
FVC %	0.02	0.88	0.38	< 0.001
FEV/FVC%	0.02	0.86	0.38	< 0.001
6MWD (m)	0.10	0.38	0.36	0.001

***: Person correlation coefficient, the sign before r denote the direction of linear relationship, P < 0.05 considered significant.**

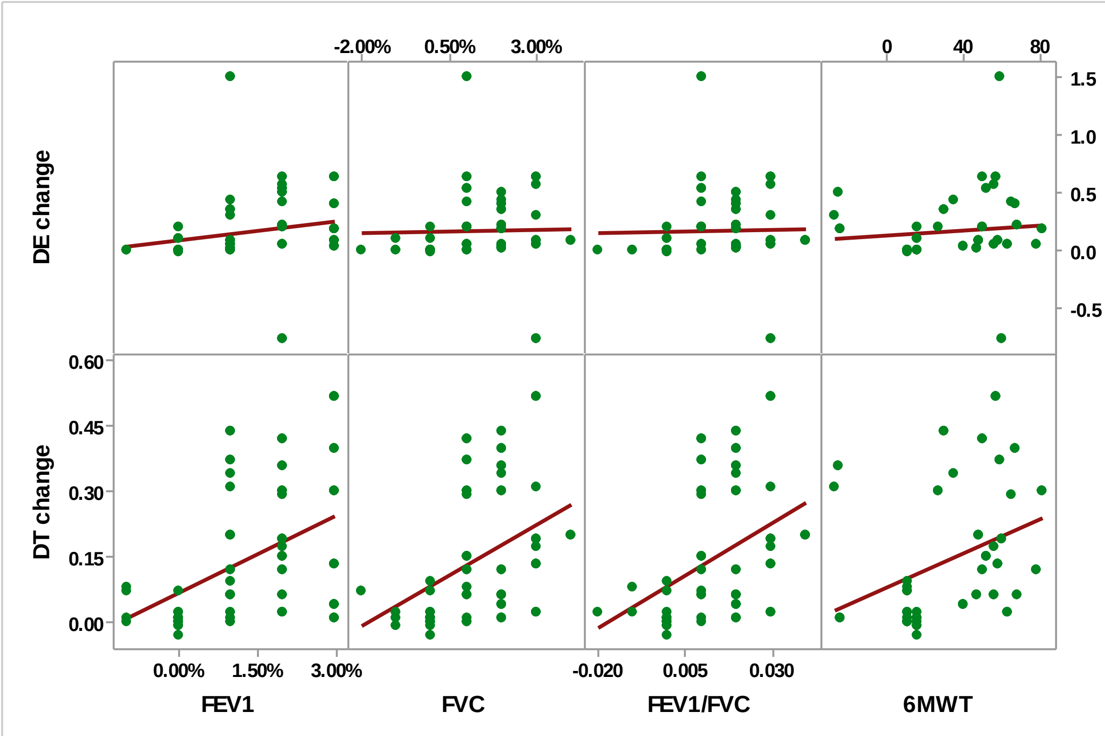

Figure (7): DE and DT changes in correlation of spirometry function

The correlation between DT changes and the changes in spirometric function was significantly positive, P < 0.001. In spite of there is positive linear correlation of DE and other parameters but it was extremely weak.

Table (7): Correlation between changes in DE and DT with SGRQ parameters

Variable	DE change		DT change	
	R	P	R	P
Total-SGRQ	-0.41	< 0.001	-0.58	< 0.001

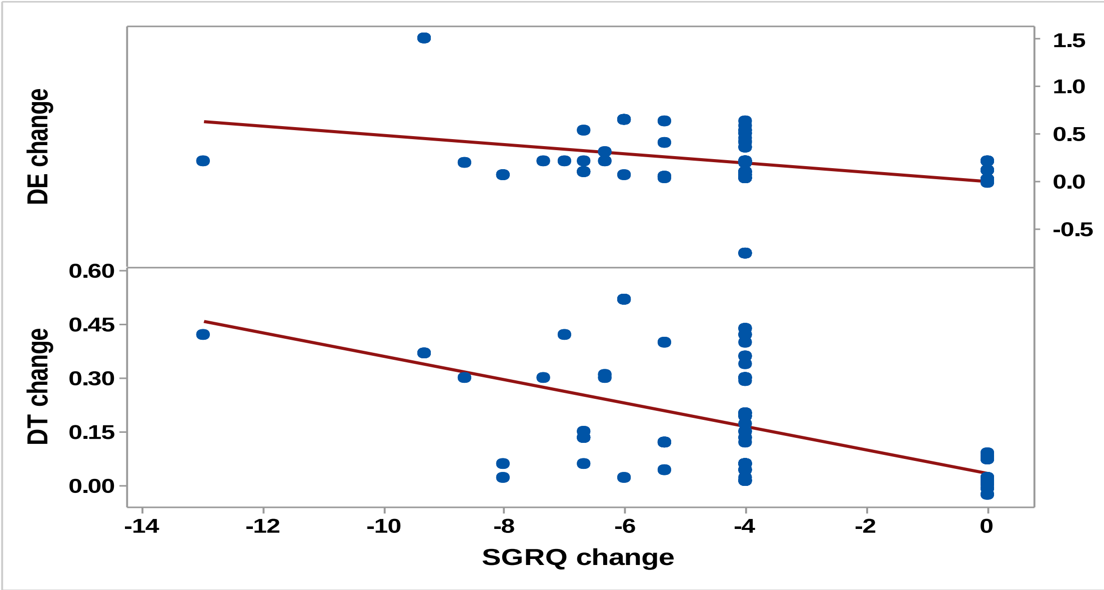

Figure (8): DE and DT changes in correlation with SGRQ score change

The linear relationship between DE and DT changes and the changes in SGRQ score were significantly negative, P < 0.001 for both.

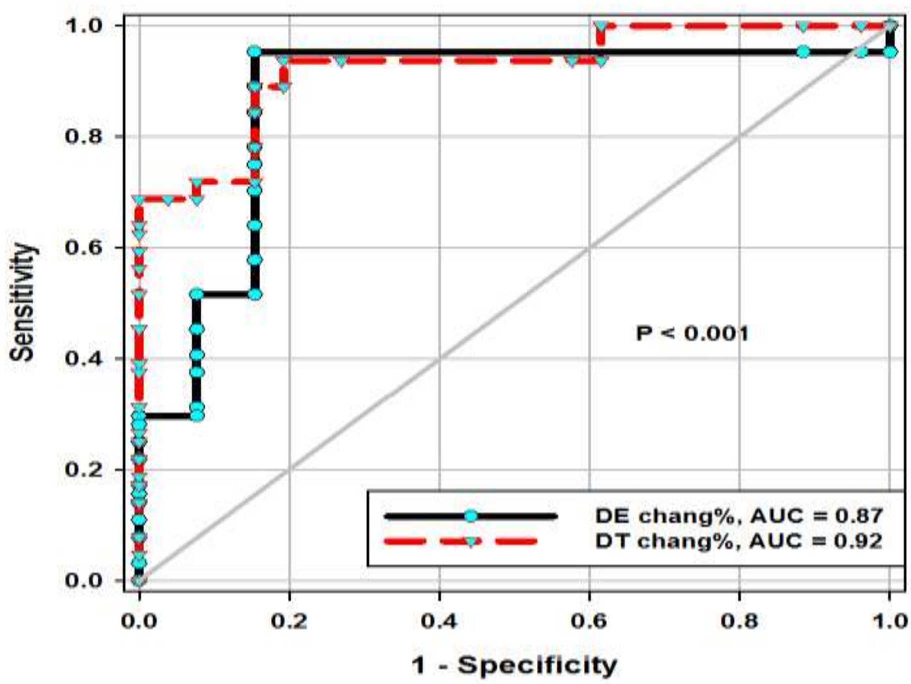

Figure (9): ROC curve for DE and DT change %.

Percentage change of both DE and DT showed significant capability in predicting successful rehabilitation, the AUC were 87 and 92% respectively, P < 0.001 for both. The best cutoff point of percentage change in DE and DT was 24 and 2% respectively with sensitivity, specificity, PPV and NPV about (95, 85, 58 and 99%; 94, 81, 52, and 98%) respectively.

IV. Discussion

In the present study, the mean total SGRQ of COPD patients was 43.25 before pulmonary rehabilitation program and significantly lowered to 39.64 with significant improvement by 10% after pulmonary rehabilitation**.** Depending on SGRQ changes limits, the prevalence of successful rehabilitation after 12 weeks of program was 71.1%. Rate of successful rehabilitations varied between studies and ranged between 56 to 88%.[20-22]

Considering the pulmonary function of patients at the baseline of rehabilitation program, the mean predicted FEV_1%, FVC% and FEV_1/FVC were 60%, 59% and 59% respectively. They showed significant improvement after pulmonary rehabilitation program; 2% change difference in FEV_1%, FVC% and FEV_1/FVC with mean value about 61%, 60% and 60% respectively.

In correlating that change in spirometric data with outcome of pulmonary rehabilitation, we reported that parameters were significantly higher in successful rehabilitation group than in failed group, hence the mean FEV_1%, FVC% and FEV_1/FVC were 67%, 64% and 64 % respectively in successful group opposite to 47%, 52% and 52% in failed one, ($P < 0.001$)

This agrees with Scott et al. [19]who found that, the majority of subjects were men (58%) with a (mean± SD) age of (69±10) years. The successful participants had a greater FEV_1 (1.1 L versus 0.9 L; $P<0.05$) and FEV_1 predicted (40.7% versus 36.6%).

In similarity with Crimi et al.[9] found he changes in FEV_1%, FVC% and FEV_1/FVC were significant after 12 week of pulmonary rehabilitation program; they were 43%, 83% and 41% respectively opposite to 48%, 89% and 53% after pulmonary rehabilitation.

Many studies were not able to detect significant changes in forced expiratory volume in the first second (FEV_1), forced vital capacity (FVC), and FEV_1/FVC values after pulmonary rehabilitation.[23,24]

Regarding the grade of dyspnea and capability of 6MW test; the present work reported that, before pulmonary rehabilitation program, the mean mMRC dyspnea scale of patients was 2.04 with a rang from (2-3) while the mean 6MWD was (410 m). They showed significant changes after the end of the program, as they recorded about 35% and 9% improvement for mMRC dyspnea scale and 6MWD respectively**.** The change was significantly higher in successful pulmonary rehabilitation group than in failed one, hence mMRC dyspnea scale was 1 mean in successful rehabilitation group opposite to 1.42 in failed pulmonary rehabilitation group, and mean 6MWD was 468.3 in successful pulmonary group opposite to 368 m in failed group respectively.

This agrees with Xu et al.[25], they found that; exercise tolerance measured by 6MWT and dyspnea level determined through mMRC were significantly improved after 12 weeks of modified pulmonary rehabilitation.

Also Sundararajan et al.[26] investigated the specific effect of a 6-week outpatient pulmonary rehabilitation program and found an improvement in walking distance, dyspnea score, and health status.

Many studies have shown that pulmonary rehabilitation reduces dyspnea on exertion, increases exercise capacity and improves health-related quality of life (QOL) in COPD patients.[27,14]

The current results came in contrast with Scott et al. [19], they found that there were insignificant difference between successful pulmonary rehabilitation group and failed group as regarding mMRC and 6MWD, (2.9±0.9 vs 3.1±0.8) and (327±108 m vs 310±104 m) respectively. The reasonable explanation was that; even with increasing all exercise parameters from base line and after the end of pulmonary rehabilitation program in failed group but it was not sufficient to reach the significant level.

Zanforlin et al.[28] added US analysis of the diaphragmatic excursion and correlated it with bronchial obstruction.

In the present study, US diaphragmatic examination reported that; before pulmonary rehabilitation program, the mean DE was about 3 cm, while mean DT about 1 cm and showed 6% and 15% improvement respectively after pulmonary rehabilitation, hence it increased to reach 3.15 cm and 1.17 cm mean with $P < 0.001$ for both . Moreover, the correlation of DT changes was significantly positive with spirometric function and exercise performance (6MWD), $P < 0.001$. On the other hand, the correlation of DT and DE changes with SGRQ score were significantly negative, $P < 0.001$ for both.

In addition, the ability of DE and DT changes (%) in prediction of successful pulmonary rehabilitation was examined in the present work using ROC analysis, it showed significant capability, the AUC were 87 and 92% respectively, $P < 0.001$ for both. The best cutoff point of % change in DE and DT were 24% and 2% respectively with sensitivity, specificity, PPV and NPV about (95, 85, 58 and 99%; 94, 81, 52, and 98%) respectively.

The present work strengthened the results of Crimi et al.[9], they measured DT at Zapp using B-mode of US and DE of RT hemi-diaphragm during quiet and deep breathing by M-mode, and they found significant changes in both DT and DE before and after pulmonary rehabilitation, $P < 0.001$ for all. In addition, the performance of DT in their study was acceptable in discriminating the successful pulmonary rehabilitation from failed group, hence, regarding their definition of successful pulmonary rehabilitation; those with improved 6MWD, the AUC = 83%, best cutoff point (10%), with sensitivity and specificity 83% and 74% respectively. While in other with improved CAT score after pulmonary rehabilitation, the AUC = 76%, best cutoff point was (9%), with sensitivity and specificity 80% and 62% respectively.

On different view; Seymour et al. [29] discussed the utility of ultrasound measurements of the rectus femoris area as a noninvasive tool of measuring muscle mass change in patients who underwent pulmonary rehabilitation. Their results were supporting the idea of capability of US to estimate any muscular changes during pulmonary rehabilitation program with acceptable performance level.

Moreover, from another scope, Chun et al.[30] used fluoroscopy imaging to evaluate diaphragmatic movement before and after pulmonary rehabilitation in COPD patients, and they found significant difference in diaphragmatic mobility after the end of pulmonary rehabilitation program, and concluded that the pulmonary rehabilitation program perform a significant impact as regarding diaphragm muscle even with insignificant improvement of pulmonary functions.

V. Conclusion:

Diaphragmatic ultrasound examination of stable COPD patients undergoing pulmonary rehabilitation is accurate and reliable method for assessing diaphragmatic function and improvement.The early Pulmonary Rehabilitation program in stable COPD patients of mild and moderate degrees of severity gives the better outcome than those of severe degree of the disease.

References:

1. **Quaderi SA, Hurst JR.** The unmet global burden of COPD. *Glob Health EpidemiolGenom*. 2018;3:e4. Published 2018 Apr 6.
2. **Kim NS, Seo JH, Ko MH, Park SH, Kang SW, Won YH**. Respiratory Muscle Strength in Patients With Chronic Obstructive Pulmonary Disease. *Ann Rehabil Med*. 2017;41(4):659-666.
3. **Gea J, Pascual S, Casadevall C, Orozco-Levi M, Barreiro E.** Muscle dysfunction in chronic obstructive pulmonary disease: update on causes and biological findings. *J Thorac Dis*. 2015;7(10):E418-E438.
4. **Wüst RC, Degens H.** Factors contributing to muscle wasting and dysfunction in COPD patients. *Int J Chron Obstruct Pulmon Dis*. 2007;2(3):289-300.
5. **Kim HC, Mofarrahi M, Hussain SN.** Skeletal muscle dysfunction in patients with chronic obstructive pulmonary disease. *Int J Chron Obstruct Pulmon Dis*. 2008;3(4):637-658.
6. **Corhay JL, Dang DN, Van Cauwenberge H, Louis R.** Pulmonary rehabilitation and COPD: providing patients a good environment for optimizing therapy. *Int J Chron Obstruct Pulmon Dis*. 2014;9:27-39.
7. **Stendardi L, Binazzi B, Scano G.** Exercise dyspnea in patients with COPD. *Int J Chron Obstruct Pulmon Dis*. 2007;2(4):429-439.
8. **Ranu H, Wilde M, Madden B**. Pulmonary function tests. *Ulster Med J*. 2011;80(2):84-90.
9. **Crimi C, Heffler E, Augelletti T, et al.** Utility of ultrasound assessment of diaphragmatic function before and after pulmonary rehabilitation in COPD patients. Int J Chron Obstruct Pulmon Dis. 2018;13:3131-3139. Published 2018 Oct 8.
10. **Pasquale MK, Xu Y, Baker CL, Zou KH, Teeter JG, Renda AM et al.**COPD exacerbations associated with the modified Medical Research Council scale and COPD assessment test among Humana Medicare members;Int J Chron Obstruct Pulmon Dis. 2016; 11: 111–121.
11. **Global initiative for chronic obstructive lung disease (GOLD) (2019**): Global strategy for the diagnosis, management, and prevention ofchronic obstructive pulmonary disease, NHLBI/WHO workshopreport.

12. **Dajczman E, Wardini R, Kasymjanova G, Préfontaine D, Baltzan MA, Wolkove N.** Six minute walk distance is a predictor of survival in patients with chronic obstructive pulmonary disease undergoing pulmonary rehabilitation. Can Respir J.2015; 22(4): 225–229.
13. **Abbas A, Embarak S, Walaa M, Lutfy SM**. Role of diaphragmatic rapid shallow breathing index in predicting weaning outcome in patients with acute exacerbation of COPD. International Journal Of COPD.2018;13:1-7.
14. **Nici L, Donner C, Wouters E, Zuwallack R, Ambrosino N, Bourbeau J, et al.** American thoracic society/European respiratory society statement on pulmonary rehabilitation. American journal of respiratory and critical care medicine.2006;173(12):1390-413
15. **Spruit M A , Singh S J , Garvey C, ZuWallack R, Nici L, Rochester C et al**. An Official American Thoracic Society/European Respiratory Society Statement: Key Concepts and Advances in Pulmonary Rehabilitation. AJRCCM.2013 ;1888(8):e13-e64.
16. **Mahler DA, Horowitz MB.**Perception of breathlessness during exercise in patients with respiratory disease. Med Sci Sports Exerc.1994; 26:1078–1081.
17. **American College of Sports Medicine.** American College of Sports Medicine position stand: progression models in resistance training for healthy adults. Med Sci Sports Exerc.2009;41:687–708.
18. **Collins EG, Langbein WE, Fehr L,O'Connell S, Jelinek C, Hagarty E et al.**Can ventilation feedback training augment exercise tolerance in patients with chronic obstructive pulmonary disease? Am J RespirCrit CareMed.2008;177:844–852.
19. **Scott AS, Baltzan MA, Fox J, Wolkove N**. Success in pulmonary rehabilitation in patients with chronic obstructive pulmonary disease. Canadian respiratory journal.2010;17(5):219-23.
20. **Evans RA, Singh SJ, Collier R, Williams JE, Morgan MD**. Pulmonary rehabilitation is successful for COPD irrespective of MRC dyspnoea grade. Respir Med.2009;103:1070-5.
21. **Garrod R, Marshall J, Barley E, Jones PW**. Predictors of success and failure in pulmonary rehabilitation. EurRespir J.2006;27:788-94.
22. **Vagaggini B, Costa F, Antonelli S, De Simone C, De Cusatis G, Martino F, Santerini S, Paggiaro P.** Clinical predictors of the efficacy of a pulmonary rehabilitation programme in patients with COPD. Respir Med.2009;103:1224-30.
23. **Vogiatzis I, Williamson AF, Miles J, Taylor IK**. Physiological response to moderate exercise workloads in a pulmonary rehabilitation program in patients with varying degrees of airflow obstruction. Chest.1999;116(5):1200–1207.
24. **Karapolat H, Atasever A, Atamaz F, Kirazli Y, Elmas F, Erdinç E**. Do the benefits gained using a short-term pulmonary rehabilitation program remain in COPD patients after participation? Lung.2007;185(4):221–225.
25. **Xu J, He S, Han Y, Pan J, Cao L.** Effects of modified pulmonary rehabilitation on patients with moderate to severe chronic obstructive pulmonary disease: A randomized controlled trail. International journal of nursing sciences.2017; 10;4(3):219-24.

26. **Sundararajan L, Balami J, Packham S.** Effectiveness of outpatient pulmonary rehabilitation in elderly patients with chronic obstructive pulmonary disease. Journal of cardiopulmonary rehabilitation and prevention.2010;30(2):121-5.
27. **Goldstein RS, Hill K, Brooks D,Dolmage TE.** Pulmonary rehabilitation: a review of the recent literature. Chest.2012; 142(3):738-49.
28. **Zanforlin A, Smargiassi A, Inchingolo R, di Marco Berardino A, Valente S, Ramazzina E.** Ultrasound analysis of diaphragm kinetics and the diagnosis of airway obstruction: the role of the M-mode index of obstruction. Ultrasound Med Biol.2014;40(6):1065–1071.
29. **Seymour JM, Ward K, Sidhu PS, Puthucheary Z, Steier J, Jolley CJ et al.**Ultrasound measurement of rectus femoris cross-sectional area and the relationship with quadriceps strength in COPD. Thorax.2009;64(5):418–423.
30. **Chun EM, Han SJ, Modi HN.** Analysis of diaphragmatic movement before and after pulmonary rehabilitation using fluoroscopy imaging in patients with COPD. International journal of chronic obstructive pulmonary disease.2015;10:193.