



Correlation Of Diaphragmatic Excursion and Six Minute Walk Distance in Patients with Chronic Obstructive Pulmonary Diseases.

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ABSTRACT

Background: Chronic Obstructive Pulmonary Disease (COPD) impairs pulmonary function, diaphragm mobility, and exercise capacity. This study aimed to investigate the relationship between diaphragm excursion and six-minute walk distance (6MWD) in COPD patients compared to healthy controls.

Methods: This observational cross-sectional study included 33 clinically diagnosed COPD patients and 33 age- and gender-matched healthy controls. Diaphragm excursion was measured using M-mode ultrasonography, and functional capacity was evaluated using the six-minute walk test (6MWT). Pulmonary function and anthropometric data were recorded. Data were analysed using t-tests, Pearson correlation, and Kruskal-Wallis test.

Results: Participants in both groups had a mean age of 57 years, with 82% males. Among COPD patients, 66.66% had severe disease, 27.27% moderate, and 6.06% mild. BMI distribution varied, with over 50% of COPD patients either overweight or obese. Mean right diaphragm excursion was significantly lower in COPD patients (1.91 ± 0.60 mm) than controls (3.52 ± 0.41 mm), $p = 0.00$. Left diaphragm excursion was also significantly reduced in COPD patients (2.12 ± 0.77 mm vs. 3.43 ± 0.41 mm, $p = 0.00$). Mean 6MWD was significantly reduced in the COPD group (353.67 ± 72.60 m vs. 430.27 ± 29.23 m, $p = 0.00$).

There was a weak, statistically insignificant correlation between diaphragm excursion and 6MWD. No significant difference was found in 6MWD or diaphragm excursion across COPD severity levels.

Conclusion:

COPD patients exhibit significantly reduced diaphragm excursion and 6MWD compared to healthy controls. However, diaphragm excursion does not significantly correlate with 6MWD or disease severity.

Keywords:

COPD, Diaphragm Excursion, Six-Minute Walk Test, Ultrasonography, Functional Capacity.

INTRODUCTION:

India has a disproportionately high burden of chronic respiratory diseases. The contribution of chronic respiratory diseases to the total DALYs in India is 6.4% (Pati & Suliankatchi, 2018). The Global Burden of Disease Study reported the prevalence of COPD in India as 4.4% in 2016 (Verma et al., 2021). However, a recent meta-analysis reported a 7% prevalence of COPD



in the population above 30 years of age in India (Verma et al., 2021). A cross-sectional study by Renthlie et al. reported the prevalence of asthma–COPD overlap syndrome (ACO) as 22% among previously diagnosed COPD patients in India (Renthlie et al., 2019). Among all chronic obstructive airway diseases (COADs), the prevalence of obliterative bronchiolitis was found to be 23% (Suhas et al., 2019).

Chronic Obstructive Pulmonary Disease (COPD) is a heterogeneous lung condition characterized by chronic respiratory symptoms (dyspnoea, cough, sputum production, exacerbations) due to abnormalities of the airways (bronchitis, bronchiolitis) and/or alveoli (emphysema), which cause persistent, often progressive, airflow limitation (GOLD, 2020). COAD is an umbrella term that includes all conditions with irreversible or poorly reversible airway obstruction, such as chronic bronchial asthma, COPD, and post-infectious obliterative bronchiolitis. The pathophysiology of COPD is marked by chronic inflammation of the airways, alterations in repair mechanisms and airway remodelling, oxidative stress imbalance, and the "spill-over" of inflammatory mediators into the systemic circulation. These systemic effects result in manifestations such as unintentional weight loss, increased risk of cardiovascular disease, skeletal muscle dysfunction, osteoporosis, and depression (Barnes & Celli, 2009; Agusti & Soriano, 2008). Chronic inflammation causes structural changes and narrowing of the small airways, along with luminal exudates, which reduce lung elastic recoil. These changes impair the ability of the airways to remain open during expiration. As a result, lung emptying during forced expiration is limited, leading to a decreased FEV₁/FVC ratio and FEV₁, and contributing to gas trapping and lung hyperinflation (Gagnon et al., 2014).

In COPD, static lung hyperinflation is primarily related to the loss of elastic recoil. This reduces inspiratory capacity and often leads to dynamic hyperinflation during exercise due to airflow limitation. These mechanisms result in exertional dyspnoea and reduced exercise capacity (Gagnon et al., 2014). Hyperinflation alters the mechanics of respiration, causing the inspiratory muscles particularly the diaphragm to operate at shorter-than-normal lengths. The length tension relationship of the inspiratory muscles is compromised. Diaphragmatic fibres are shortened, reducing their range of contraction. The diaphragm flattens, and its angle of pull becomes more horizontal, decreasing the zone of apposition. This reduces its ability to lower intrathoracic pressure and descend effectively during inspiration. Consequently, the diaphragm's rib cage expanding action is diminished, and in severe cases, diaphragmatic contraction may cause rib cage deflation instead of expansion. As a result, breathing becomes more reliant on accessory inspiratory muscles. The increased neural drive required to maintain ventilation during exertion leads to the sensation of dyspnoea in COPD patients, ultimately reducing their exercise tolerance (De Troyer, 1997).

Diaphragmatic excursion refers to the amplitude of the craniocaudal movement of the diaphragm during breathing (Azour et al., 2021). It can be measured using various imaging modalities, including fluoroscopy, CT, MRI, chest radiography, and ultrasound. Each technique has its own advantages and limitations in terms of cost, radiation exposure, and availability.



Ultrasound is an accurate, reproducible, and portable method for assessing diaphragmatic mobility (Boussuges et al., 2020). The diaphragm is visualized in B-mode (two-dimensional), and the amplitude of its craniocaudal movement is measured using M-mode (one-dimensional) (Boussuges et al., 2020).

Functional capacity is defined as an individual's maximum ability to perform activities of daily living that require sustained aerobic metabolism (Boussuges et al., 2020). The 6-Minute Walk Test (6MWT) is a practical, simple, and self-paced test that assesses the submaximal level of functional capacity. Most patients do not reach their maximal exercise capacity during the 6MWT, as they are allowed to choose their own pace and take rest breaks if needed. However, since most daily activities are performed at submaximal levels of exertion, the 6-Minute Walk Distance (6MWD) may better reflect functional exercise performance in real-life settings (ATS Committee, 2002).

There is a paucity of literature on the relationship between diaphragmatic excursion and functional capacity in patients with obstructive airway diseases in the Indian population. Furthermore, considering the high prevalence of post-infectious obliterative bronchiolitis—a condition that also presents as an obstructive airway disease—in India, there is a need to study the correlation between diaphragmatic excursion and functional capacity in Indian COPD patients.

METHODS:

This observational cross-sectional study was conducted over six months (January to June 2023) in a tertiary care hospital. The study aimed to assess the relationship between diaphragmatic excursion and functional capacity in patients with COPD compared to age- and gender-matched healthy individuals.

Participants were divided into two groups: Group A (33 COPD patients) and Group B (33 healthy controls). Both groups were recruited using convenient sampling from the Pulmonary Medicine and Physiotherapy OPDs. Sample size was calculated using G*Power 3.1, based on an expected correlation coefficient of $r = 0.56$ (An et al., 2021), with 95% confidence and 90% power.

Inclusion criteria for Group A were $FEV_1/FVC < 70\%$ and the ability to follow instructions. Group B included healthy individuals with $FEV_1/FVC > 70\%$. *Exclusion criteria* for both groups included recent exacerbation, abnormal vitals (SBP < 100 or > 140 mmHg, DBP > 100 mmHg, HR > 120 bpm), dyspnea at rest (MMRC Grade 4), or more than two positive responses on the PAR-Q.

Data collection took place in the Physiotherapy, Pulmonary Medicine, and Radiology OPDs. Instruments used included a weighing scale, measuring tape, pulse oximeter,



sphygmomanometer, stopwatch, Coach 2® volume spirometer, and a Samsung RS80 ultrasound machine (3.5 MHz probe).

Functional capacity was measured using the Six-Minute Walk Test (6MWT), following ATS guidelines, and reported as the distance walked in meters. Diaphragm excursion was assessed via M-mode ultrasonography, performed by a radiologist during quiet and deep breathing.

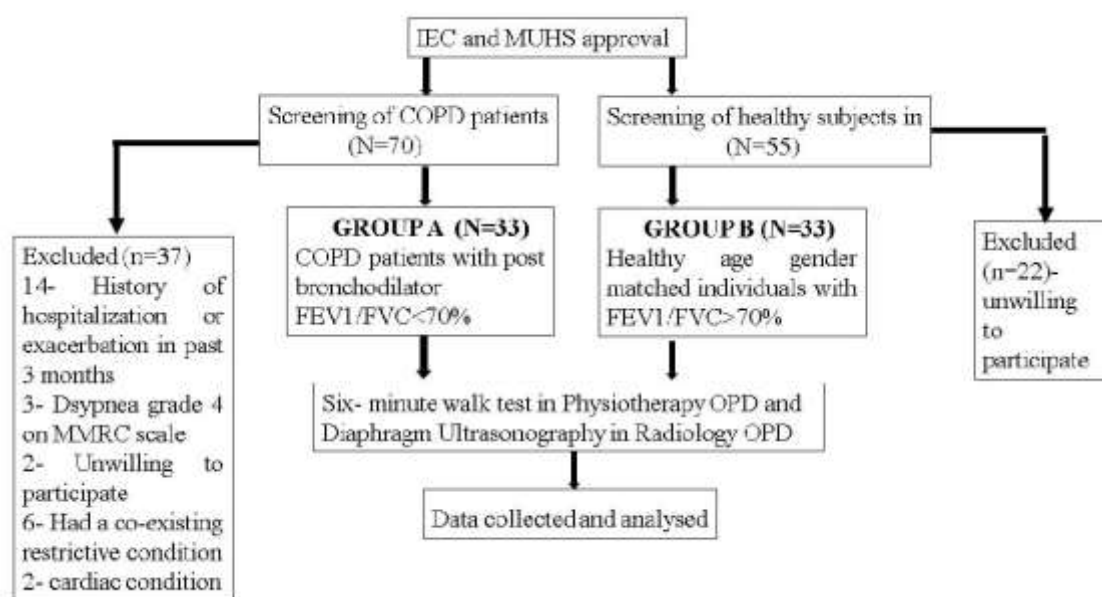
All participants provided written informed consent, and the study was approved by the Institutional Ethics Committee.

PROCEDURE:

Ethical approval was obtained from the Institutional Ethics Committee (IEC), Departmental Review Board (DRB), and Maharashtra University of Health Sciences (MUHS). Permissions were also secured from the Chest Medicine and Radiology Departments for conducting the study.

COPD patients attending the Chest Medicine and Physiotherapy OPDs of the tertiary care hospital who met the inclusion criteria were screened and enrolled in Group A after obtaining written informed consent. Age- and gender-matched healthy individuals visiting the hospital, meeting inclusion criteria, were enrolled in Group B after informed consent. Pulmonary Function Tests (PFT) for both groups were conducted in the Chest Medicine OPD.

Baseline Data Collection: Demographic details and baseline vitals including resting blood pressure, heart rate, respiratory rate, and oxygen saturation (SpO₂) were recorded for all participants.





Six-Minute Walk Test (6MWT): The 6MWT was conducted in the Physiotherapy OPD following the American Thoracic Society (ATS) guidelines. Pre-test vitals; blood pressure, heart rate, respiratory rate, SpO₂, and dyspnoea level using the Modified Borg Scale (0-10) were measured and recorded. Participants were instructed to walk as fast as possible along a marked 30-meter hallway for six minutes. They were allowed to rest by sitting on a chair if they felt fatigued or breathless during the test. The maximum distance covered in six minutes (6MWD) was recorded for analysis. Post-test vitals were recorded immediately, as well as at 1 and 3 minutes after the test, primarily for safety monitoring but were not included in the statistical analysis.

Diaphragm Excursion Measurement: Diaphragmatic movement was assessed using a Samsung RS 80 high-resolution ultrasound machine with a 3.5 MHz convex transducer, performed by a radiologist in the Radiology OPD. Participants were positioned in a quarter-turn semi-recumbent position, supported by pillows for comfort. The transducer was placed transversely at the mid-axillary line over the lower intercostal space to visualize the three-layered diaphragm image. M-mode ultrasound was used to measure diaphragmatic excursion in millimetres separately for both hemidiaphragms.

Breathing Standardization: To minimize variability due to lung volume differences, participants were first instructed on maximal inspiration using a volume spirometer (Coach 2). The maximal inspiratory capacity was measured, and 70% of this value was calculated. Participants practiced breathing at 70% of their maximal capacity, and during the ultrasound examination, they were asked to inspire at this standardized volume. Three measurements of diaphragmatic excursion were recorded, and the highest value was used for statistical analysis.

Picture 1: Participant training on volume spirometer



Picture 2: Radiologist doing ultrasonography of diaphragm.



Picture 3: Participant walking during 6MWT.



RESULT:

Table No. 1: Descriptive Statistics of Age distribution of Group A and Group B

The above table shows descriptive analysis of age of patients with COPD (group A). Mean age

	N	Minimum	Maximum	Mean	Median	Standard Deviation
AGE of Group1(years)	33	23	72	56.88	57.00	11.08
AGE of Group2(years)	33	23	70	56.484	57.00	10.65

of the subjects was 56.00 ± 11.08 . Median age of the subjects was 57.00. Mean age of controls was 56.484 and median age was 57.00. Mann-Whitney U test was conducted between study and control group to check variance in age of participants. It showed $p=0.817$ i.e. not significant difference. This shows that the two groups were age matched.

Table No.2. Gender Distribution of the Participants



GENDER	N	Percentage
MALE	27	81.81
FEMALE	06	18.18
TOTAL	33	100.00

The above table shows that there were 27 (82%) male participants and 06 (18%) female participants in the study.

Table No. 3: Descriptive Statistics of BMI in Group A and Group B

		Underweight	Normal	Overweight	Obesity class 1
GROUP A	N = 33	3	11	9	10
	Percentage	9.09	33.33	27.27	30.30
GROUP B	N = 33	0	11	15	7
	Percentage	0	33.33	45.45	21.21

Out of 33 cases, 3 (9.09%) were underweight, 11 (33.33%) had normal BMI, 9 (27.27%) were overweight and 10 (30.30%) were Obesity Class 1. Out of 33 controls, 0 (0%) were underweight, 11 (33.33%) had normal BMI, 15 (45.45%) were overweight and 7 (21.21%) were Obesity Class 1.

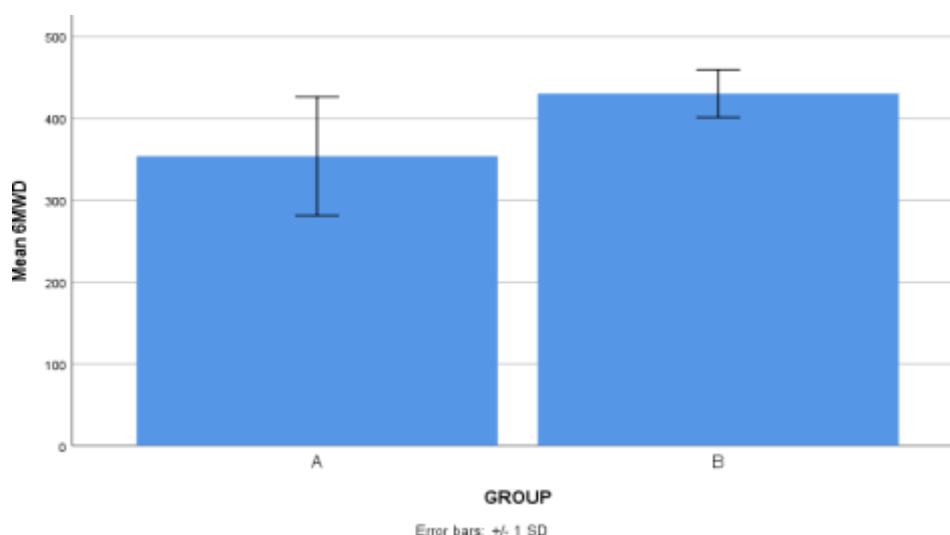


Table No.4: Distribution of Severity of airflow obstruction in COPD patients (Group1)

Severity of Airflow obstruction	N	Percentage
Mild ($FEV_1 \geq 80\%$ predicted)	02	6.00
Moderate ($80\% \leq FEV_1$ %predicted $\geq 50\%$)	09	27.27
Severe ($50\% \leq FEV_1$ %predicted $\geq 30\%$)	22	66.66
Very Severe (FEV_1 %predicted $\leq 30\%$)	00	00

The above table shows the distribution of severity of disease i.e. airflow obstruction in COPD patients. Out of 33 patients, 2 patients (6%) were of mild severity, 9 patients (27%) were of moderate severity and 22 patients (67%) were having severe airflow obstruction. None of the patients had very severe obstruction.

Graph No. 1: Descriptive analysis of 6MWD in both groups





The above graph shows descriptive statistics of 6MWD in both COPD patients (group A) and control group (group B). The mean distance walked by COPD patients was 353.67 ± 72.604 . The mean distance walked by participants in control group was 430.27 ± 29.23

Table No.5: Unpaired t test for 6MWD between both groups

Variable	Group A (Mean $\pm$ SD)	Group B (Mean $\pm$ SD)	t value	Mean Difference	95 % CI of the Difference		P value
					Lower	Upper	
6MWD	353.67 ± 72.604	430.27 ± 29.23	-5.623	-76.606	-104.099	-49.113	< 0. 001*

The results of the independent samples t-test between group A and 2 showed significant differences in mean scores of 6MWD between COPD patients and healthy controls ($t = -5.623$, $p = < 0.001$)

Table No. 6: Descriptive statistics of Diaphragm excursion on right and left side in group A and group B

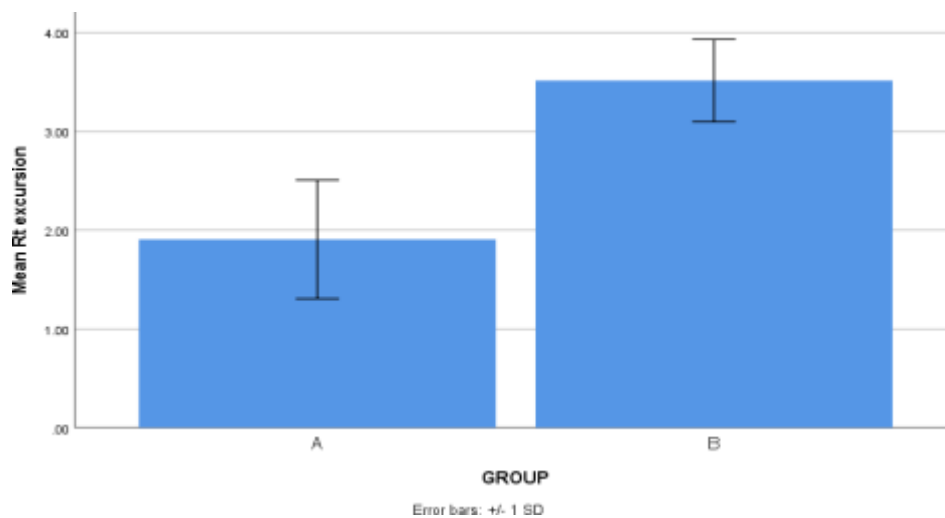
Variable	Group A (Mean $\pm$ SD)	Group A Maximum excursion	Group B (Mean $\pm$ SD)	Group B Maximum excursion	Mean difference
Right excursion	1.9067 ± 0.60072	3.2	3.5152 ± 0.41692	4.1	- 1.6085
Left excursion	2.0548 ± 0.76521	3.5	3.4352 ± 0.4175	4.1	-1.3803

The above table shows descriptive analysis of Diaphragm excursion measured on left and right side in Group A (COPD patients) and Group B (healthy controls). The mean excursion for

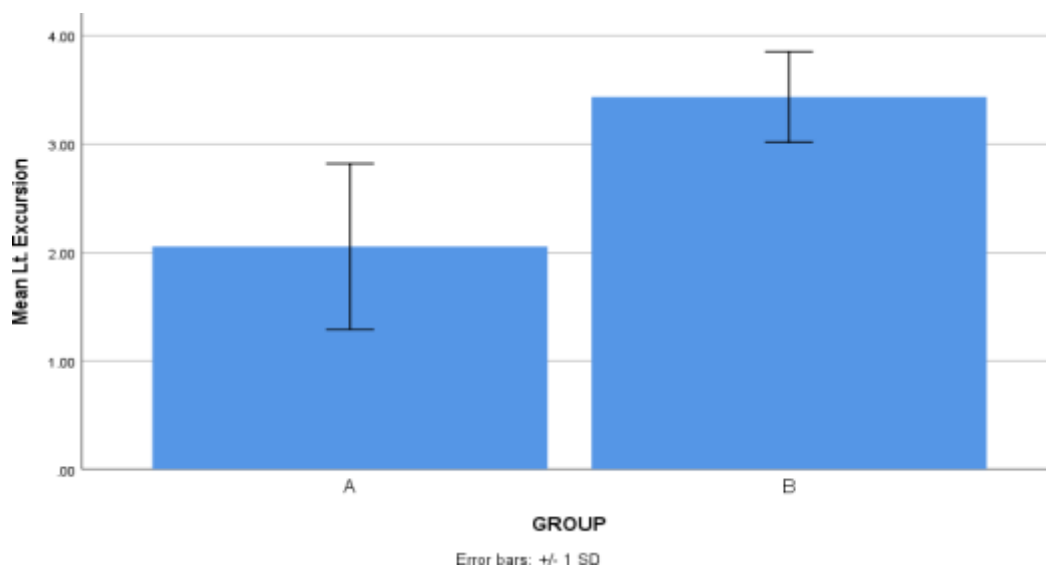


right hemidiaphragm was 1.9067 ± 0.60072 and 3.5152 ± 0.41692 for group A and group B respectively with maximum excursion of 3.2mm and 4.1 mm. The mean excursion for left hemidiaphragm was 2.0548 ± 0.76521 and 3.4352 ± 0.4175 for group A and group B respectively with maximum excursion of 3.5mm and 4.1 mm.

Graph No. 2: Descriptive statistics of Right Hemidiaphragm in Group A and Group B



Graph No.3: Descriptive statistics of Left Hemidiaphragm excursion in Group A and Group B





**Table No.7: Unpaired t test for Diaphragm excursion between group A and
group B**

Variable	Group A (Mean±SD)	Group B (Mean±SD)	t value	Mean Difference	95 % CI of the Difference		P value
					Lower	Upper	
Right excursion	1.9067 ± 0.60072	3.5152 ± 0.41692	-12.636	-1.60848	-1.86277	-1.35419	< 0. 001*
Left Excursion	2.0548 ± 0.76521	3.4352 ± 0.4175	-9.096	-1.3803	-1.68516	-1.07544	< 0. 001*

The results of the independent t-tests showed significant differences in mean scores between Group A and Group B for Right excursion ($p < 0. 001$) and Left Excursion ($p < 0. 001$)

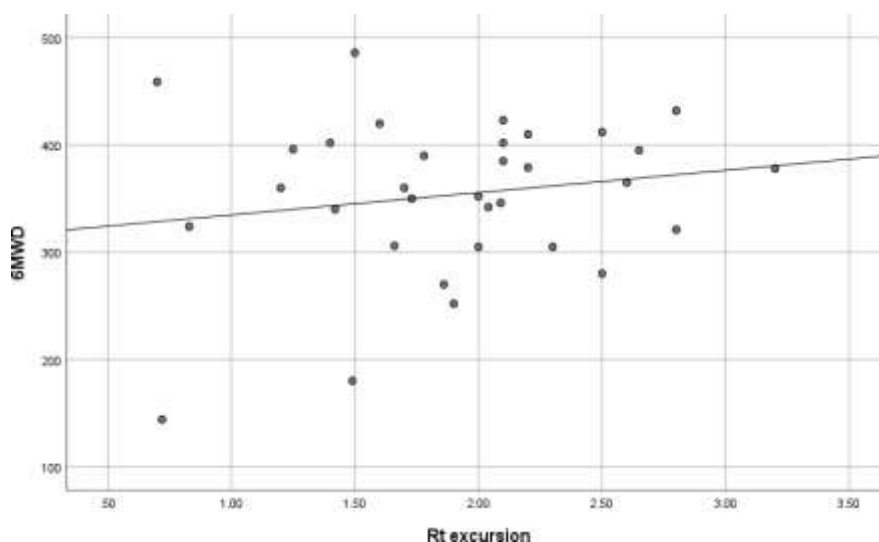
**Table No.8: Pearson Correlation between 6MWD and Diaphragm Excursion in
COPD patients (Group A)**



Correlations				
		6MWD	Right excursion	Left Excursion
6MWD	Pearson Correlation	1	0.172	0.311
	P value		0.338	0.078
	N	33	33	33

In Group A, Pearson correlation was computed to examine the relationship between Diaphragm excursion and 6MWD . However, the results indicated that none of the correlations were statistically significant.

Graph No. 4: Pearson correlation between right diaphragm excursion and 6MWD



Graph No. 5: Pearson correlation between left diaphragm excursion and 6MWD

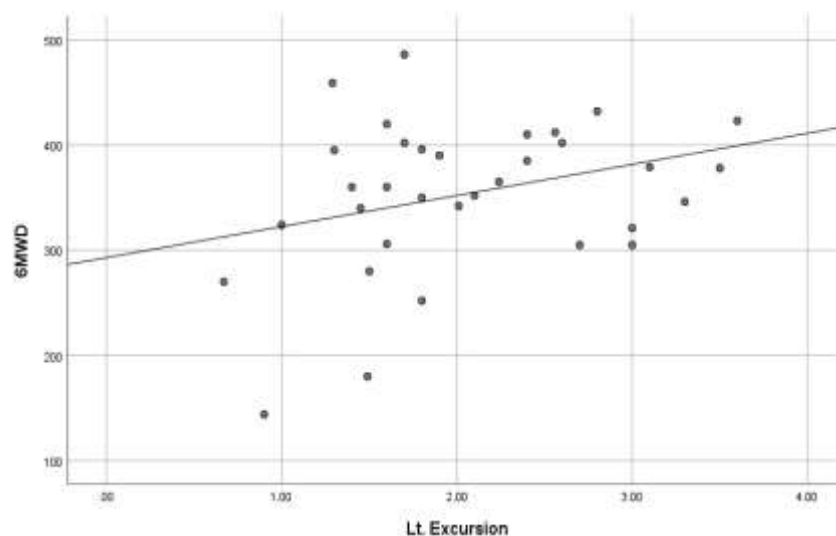


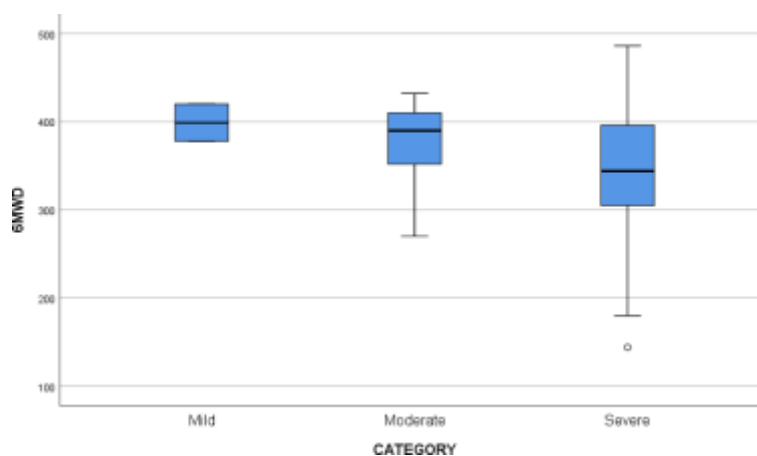
Table No.9: Kruskal Wallis test

Scale	Variable	N	Mean Rank	P value
Rt excursion	Mild	2	21.5	0.22
	Moderate	9	21.06	
	Severe	22	14.93	
Lt. Excursion	Mild	2	21.5	0.664
	Moderate	9	18.33	
	Severe	22	16.05	
6MWD	Mild	2	24	0.17
	Moderate	9	20.78	
	Severe	22	14.82	

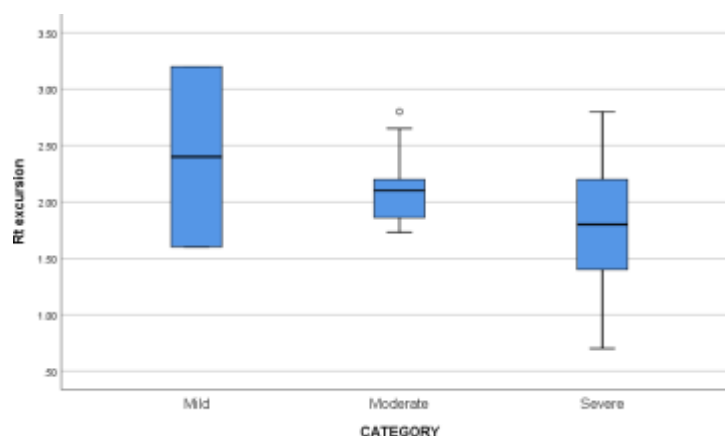
Kruskal Wallis test was conducted to assess whether there was significant difference in diaphragm excursion and 6MWD across mild, Moderate, Severe COPD categories of patients. However, the results of the Kruskal-Wallis test indicated that none of the groups showed a statistically significant difference.



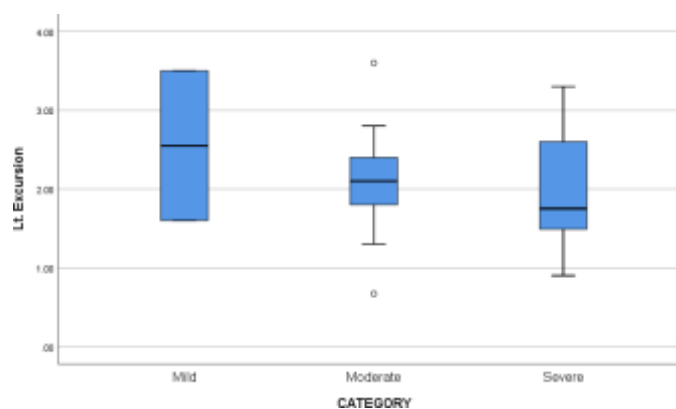
Graph No. 6: Distribution of 6MWD with respect to severity



Graph No.7: Distribution of Right diaphragm excursion with respect to severity



Graph No.8: Distribution of Left Diaphragm with respect to severity





SUMMARIZED RESULTS

33 COPD patients and 33 age gender matched healthy controls completed the study with 27 males (82%) and 6 females (18%) in each group.

The mean age of the participants in group A was 56.88years $\pm$ 11.08 years and the median age was 57 years while in group B, mean age was 56.48years $\pm$ 10.65 years and median age was 57 years.

In the study group 66.66% had severe COPD, 27.27% had moderate COPD and 6.06% had mild COPD.

Out of 33 controls, 0(0%) were underweight, 11(33.33%) had normal BMI, 15(45.45%) were overweight and 7(21.21%) were Obesity Class 1.

Of the 33 participants in study group, 9.09% were underweight, 33.33% had normal BMI, 27.27% were overweight and 30.30% were Obesity Class 1.

The Right Diaphragm excursion was 1.91 $\pm$ 0.60 mm and 3.515 $\pm$ 0.416mm in study and control group respectively. The results of the independent t test indicated that Diaphragm excursion was significantly reduced ($p=0.00$) in Study group with a mean difference of 1.608mm.

The Left Diaphragm excursion was 2.12 $\pm$ 0.77mm and 3.4352 $\pm$ 0.4175mm in study and control group respectively. The results of the independent t test indicated that Diaphragm excursion was significantly reduced ($p=0.00$) in study group with a mean difference of with a difference of 1.3803mm.

The mean 6MWD was 353.67 $\pm$ 72.604 meters and 430.27 $\pm$ 29.23 meters for study and control group respectively. The results of the independent t test indicated that 6MWD was significantly reduced ($p=0.00$) in study group with a mean difference of with a difference of 76.606 meters.

Pearson correlation indicated that correlation between right Diaphragm excursion and 6MWD ($r=0.172$, $p=0.338$) and left Diaphragm excursion and 6MWD ($r=0.311$, $p=0.078$) were not statistically significant.

The results of the Kruskal-Wallis test indicated that none of the groups showed any statistically significant difference with respect to 6MWD and diaphragm excursion within different severities

DISCUSSION:



The aim of this study was to examine the relationship between six-minute walk distance (6MWD) and diaphragmatic excursion in COPD patients. In this study, 33 COPD patients were recruited from the Pulmonary Medicine and Physiotherapy OPDs. According to GOLD guidelines, patients were categorized into mild ($FEV_1 > 80\%$ predicted), moderate ($50\% < FEV_1 \leq 80\%$ predicted), severe ($FEV_1 < 60\%$ predicted), and very severe obstruction ($FEV_1 < 30\%$ predicted). Thirty-three age- and gender-matched healthy individuals were recruited for comparison. The 6MWT was conducted in both the study and control groups. Diaphragmatic excursion for right and left hemidiaphragms was measured using M-mode ultrasound. Data were collected and analyzed.

The mean age of the COPD patients was 56.88 ± 11.08 years. As healthy individuals were matched for age, the control group's mean age was 56.48 ± 10.65 years (Table 1). There were 27 males (82%) and 6 females (18%) in the study group (Table 2, Graph 1). Since healthy individuals were matched by gender, the control group also had 27 males (82%) and 6 females (18%). Table 3 and Graph 2 show that in the study group, 3 patients (9.09%) were underweight, 11 (33.33%) had normal BMI, 9 (27.27%) were overweight, and 10 (30.30%) were class I obese. In the control group, none were underweight, 11 (33.33%) had normal BMI, 15 (45.45%) were overweight, and 7 (21.21%) were class I obese.

As indicated in Table 4 and Graph 4, in the study group, only 2 (6%) patients had mild disease, 9 (27.27%) were moderate, and 22 (66.66%) were of severe obstruction. There were no participants with very severe obstruction. Table 7 and Graph 5 show that mean diaphragmatic excursion in the study group was 1.90 ± 0.60 mm (right hemidiaphragm) and 2.05 ± 0.76 mm (left), whereas in the control group, mean diaphragmatic excursion was 3.51 ± 0.41 mm (right) and 3.43 ± 0.41 mm (left). Diaphragm excursion was significantly lower in COPD patients compared to controls ($p = 0.001$, Table 8), but it did not vary markedly by disease severity ($p = 0.22$ for right, $p = 0.66$ for left diaphragm) (Table 10, Graphs 10 & 11).

These findings corroborate those of Mahvish et al. (2020). In their study, right diaphragmatic excursion was measured by B-mode and M-mode ultrasonography in 26 COPD cases and 18 self-reported healthy controls. Lung function was assessed by spirometry. They found that diaphragm excursion was reduced in COPD compared to controls ($p < 0.05$), with a strong positive correlation between diaphragm excursion and FEV_1/FVC ($r = 0.75$, $p = 0.00$) and a weaker positive correlation with FEV_1 ($r = 0.25$, $p = 0.00$). They attributed this finding to shortening of diaphragm fibers with disease progression, which reduces ventilatory capacity and lung function.

However, studies by Amin, A. & Zedan et al. (2018) and Jain, Nair et al. (2019) did not fully support these results. Amin et al. (2018) studied diaphragmatic excursion during deep breathing and tidal breathing using M-mode ultrasonography in 40 male COPD patients and age-matched healthy controls. Their sample included 13 very severe, 13 severe, and 20 moderate COPD patients, with no mild cases. During tidal breathing, they found no significant difference in diaphragm excursion between COPD patients and controls; however, during deep breathing,



excursion was reduced in COPD patients, with positive correlations to FEV₁ ($r = 0.84$), FVC ($r = 0.72$), and FEV₁/FVC ($r = 0.80$). They reasoned that in COPD, reduced FVC (due to air trapping) and lower FEV₁ hamper diaphragmatic movement. Jain et al. (2019) compared diaphragmatic excursion in 48 COPD patients and matched controls using B-mode ultrasound. They observed reduced excursion in mild COPD (Grade A) but increased excursion in moderate to severe disease (Grades B and C according to GOLD 2019). They hypothesized that severe obstruction may induce hypoxia and compensatory hyperventilation, thereby increasing diaphragmatic motion.

In the present study, 6MWD in the study group averaged 353.67 ± 72.6 meters, whereas the control group averaged 430.21 ± 29.23 meters (Table 5, Graph 4). Table 6 shows a significant difference between study and control groups ($p = 0.00$), but 6MWD did not differ significantly by COPD severity (Table 10, Graph 9). These results are consistent with the ECLIPSE cohort by Martin et al. (2010), which included 1,795 COPD patients stratified by severity. They found that although 6MWD is reduced in COPD, considerable variation exists across severity levels. This study's findings also align with Tiffany et al. (2023), Vonbank et al. (2020), and Amin et al. (2018), which similarly showed lower 6MWD in COPD patients compared to healthy controls.

Mechanistically, in COPD airway obstruction leads to incomplete lung emptying and air trapping, causing static hyperinflation. This condition displaces the diaphragm caudally, altering its length–tension relationship, reducing mechanical advantage, and thus reducing diaphragmatic excursion. In this study, reduced excursion did not significantly correlate with disease severity; that may be due to the uneven distribution of patients across severity categories most were moderate to severe because very severe patients were often in exacerbation or unwilling to participate. In measuring diaphragm excursion, participants were instructed to breathe at 70% of their maximal capacity to minimize lung-volume bias. Arora et al. (2024) demonstrated that diaphragmatic motion varies significantly with body position in healthy adults, with the highest excursion observed in supine and half-lying positions. This suggests that positioning during ultrasonographic measurement can influence diaphragmatic excursion and should be carefully standardized in both research and clinical settings.

It was also noted that more than 50% of the COPD patients were overweight or class I obese (Table 3, Graph 3). Obesity may influence lung mechanics by reducing hyperinflation and partially restoring diaphragmatic position (Ora et al., 2011), potentially affecting excursion measurement.

Table 9 and Graphs 7 & 8 revealed weak, non-significant correlations between diaphragm excursion and 6MWD: for the right hemidiaphragm, $r = 0.172$, $p = 0.338$; for the left, $r = 0.311$, $p = 0.078$. These findings differ from those of Peng An et al. (2021), who in 42 COPD patients measured diaphragmatic excursion during tidal and deep breathing and found a significant positive correlation with 6MWD during deep breathing, and a weaker correlation during tidal



breathing. Amin et al. (2018) likewise reported a positive correlation between diaphragmatic excursion and 6MWD.

To summarize, this study demonstrates that 6MWD and diaphragmatic excursion are reduced in COPD patients compared to healthy controls, and that the correlation between them was weak and statistically insignificant. Potential factors influencing these results include uneven distribution of disease severity and the methodological choice of standardizing breathing at 70% maximum capacity during measurement. Additionally, BMI differences may have moderated diaphragmatic mechanics and outcomes.

CONCLUSION:

Diaphragmatic excursion and six-minute walk distance (6MWD) were reduced in the study group compared to the control group.

A weak, positive, but statistically insignificant correlation was observed between diaphragmatic excursion and 6MWD.

Both 6MWD and diaphragmatic excursion showed minimal variation across different severity levels in COPD patients.

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