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Original research article

A study on exercise limitation in patients with mild chronic obstructive pulmonary disease in a tertiary care hospital in Telangana

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Abstract

Aims and Objectives: To know whether there is any exercise limitation in patients with mild COPD based on inspiratory capacity. To evaluate for forced expiratory time in mild COPD.

Methods: From a period of May 2018 to April 2021, prospective observational study carried out on 30 cases of mild COPD defined by spirometry. The study was conducted in the Department of Pulmonary Medicine, Government General and Chest Hospital, Erragadda, Hyderabad, Telangana, India.

Results: These 30 cases and 20 controls were evaluated for exercise limitation by exercise testing with cycle ergometer. The parameter measured is the inspiratory capacity. There is significant decrease in the inspiratory capacity in cases after the exercise test when compared to controls which was statistically significant. There in marked limitation of exercise even in cases with mild COPD. So, early intervention and proper treatment improves the quality of life and threshold for exercise. Measurement of peak oxygen uptake would have been a better parameter for exercise limitation with better outcomes.

Conclusions: There in marked limitation of exercise even in cases with mild COPD. So, early intervention and proper treatment improves the quality of life and threshold for exercise.

Keywords: Exercise, peak oxygen uptake, Heart Rate, COPD

Introduction

Chronic obstructive pulmonary disease (COPD) is a common, preventable, and treatable disease that is characterized by persistent respiratory symptoms and airflow restriction due to abnormalities in the airways and/or alveoli, which are typically brought on by prolonged exposure to noxious substances or gases and influenced by environmental factors, including abnormal lung development [1, 2]. The fourth-leading cause of death globally is chronic obstructive pulmonary disease [3]. In 2012, there were more than 3 million fatalities worldwide, with a mortality rate of 6%. In 2008, COPD claimed the lives of 4.5 million people worldwide.

Physical inactivity mainly contributes for the progression of the disease and troublesome dyspnoea which increases the risk of hospitalization and development of co morbidities [4, 5]. Airflow obstruction in mild COPD is associated with reduced exercise capacity [4, 6]. Most patients often restrict their day to day activities to avoid dyspnoea [7] Regular physical activity reduces the risk and rate of hospitalisation and mortality in patients with COPD [4, 8]. Smoking cessation remains the most effective intervention in patients with COPD [9].

At rest, healthy people and people with mild COPD can breathe more air than when they are working out, exceeding their tidal volumes. When making crucial capacity maneuvers, they do it regularly. The patient reaches a point at which their dyspnea becomes intolerable as a result of the interaction between an elevated tidal volume demand and an elevated end inspiratory lung volume.

This threshold, known as the O Donnel threshold, is reached in COPD much more quickly than would be anticipated by maximal voluntary ventilation measured at rest [10]. The maximum amount of air that can be inspired is known as the inspiratory capacity. It occurs after a quiet expiration that ends the expiratory lung volume. Indirect measurement of lung hyperinflation is the inspiratory capacity. Changing serial inspiratory capacity from resting value, under the premise that TLC stays stable, allows us to measure dynamic hyperinflation during exercise. In patients with chronic obstructive pulmonary disease, a decline in inspiratory capacity is a significant predictor of mortality and is linked to a reduced ability to exercise.

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There is no sufficient data in the literature regarding limitations in exercise in mild COPD. The present study was conducted to know whether there is limitation in exercise in mild COPD cases with respect to inspiratory capacity.

Materials and Methods

From a period of May 2018 to April 2021, prospective observational study carried out on 30 cases of mild COPD defined by spirometry. The study was conducted in the Department of Pulmonary Medicine, Government General and Chest Hospital, Erragadda, Hyderabad, Telangana, India.

Inclusion criteria

- Individuals over 18 years of age.
- Patients diagnosed with mild stable COPD defined by GOLD guidelines
- Cooperative patient
- Smokers, non-smokers

Exclusion criteria

- Those that did not meet inclusion criterias
- Those diagnosed with Moderate and severe COPD defined by GOLD guidelines
- Cardiovascular and peripheral muscular diseases.
- Other musculoskeletal diseases.

Results

Age distribution in the study

The mean age of cases is 39.9 and controls is 39.3

Table 1: Age distribution in the study

Age (Years)	Group	
	Case	Control
Mean (SD)	39.90 (6.00)	39.30 (6.80)
Median (IQR)	38.5 (36-43)	39.5 (34.75-45.25)
Range	28 – 55	27 – 50

Gender distribution in the study

Out of the 30 cases in the study 23 were males and 7 were females. Out of the 20 controls 15 were males and 5 were females

Table 2: Gender distribution in the study

Gender	Group		
	Case	Control	Total
Male	23 (76.7%)	15 (75.0%)	38 (76.0%)
Female	7 (23.3%)	5 (25.0%)	12 (24.0%)
	30 (100.0%)	20 (100.0%)	50 (100.0%)

BMI in the study

The mean BMI in the case group was 24.8 where, as the mean BMI in the controls is 23.4

Table 3: BMI distribution in the study

BMI (Kg/m2)	Group	
	Case	Control
Mean (SD)	24.85 (3.15)	23.44 (1.57)
Median (IQR)	24.25 (22.9-25.9)	22.75 (22.5-24.3)
Range	19.6 - 31.2	21.9 – 28

Cough in the study

Out of the 30 cases.10 had history of cough whereas the rest of 20 cases were without cough. All the 20 controls were asymptomatic.

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Table 4: Cough in the study

Cough	Group		
	Case	Control	Total
Present	10 (33.3%)	0 (0.0%)	10 (20.0%)
Absent	20 (66.7%)	20 (100.0%)	40 (80.0%)
Total	30 (100.0%)	20 (100.0%)	50 (100.0%)

Smoking in the study

Out of the 30 cases in the study 22 were smokers and the rest 8 were nonsmokers.in the control group all the 20 were non-smokers.

Table 5: Smoking in the study

Smoking	Group		
	Case	Control	Total
Present	22 (73.3%)	0 (0.0%)	22 (44.0%)
Absent	8 (26.7%)	20 (100.0%)	28 (56.0%)
Total	30 (100.0%)	20 (100.0%)	50 (100.0%)

Second Hand Smoke Exposure in the study

4 cases out of the 8 in smokers had history of second-hand smoke exposure. 4 controls out of the 20 had second hand smoke exposure.

Table 6: Second hand smoke in the study

Second hand smoke exposure	Group		
	Case	Control	Total
Present	4 (50.0%)	4 (20.0%)	8 (28.6%)
Absent	4 (50.0%)	16 (80.0%)	20 (71.4%)
Total	8 (100.0%)	20 (100.0%)	28 (100.0%)

Biomass Exposure in the study

Out of the 17 cases out of 30 has biomass exposure and 6 out of 20 controls has exposure to biomass.

Table 7: Biomass exposure in the study

Biomass Exposure	Group		
	Case	Control	Total
Present	17 (56.7%)	6 (30.0%)	23 (46.0%)
Absent	13 (43.3%)	14 (70.0%)	27 (54.0%)
Total	30 (100.0%)	20 (100.0%)	50 (100.0%)

Borg Scale (Before Exercise)

All the 30 cases has borg scale of 0 before exercise and all the 20 controls were with borg scale of grade 0.

Table 8: Borg scale in the study (before exercise)

Borg Scale (Before Exercise)	Group		
	Case	Control	Total
Grade 0	0 (0.0%)	20 (100.0%)	20 (40.0%)
Grade 1	30 (100.0%)	0 (0.0%)	30 (60.0%)
Total	30 (100.0%)	20 (100.0%)	50 (100.0%)

Table 9: Borg scale in the study (after exercise)

Borg Scale (After Exercise)	Group		
	Case	Control	Total
Grade 1	0 (0.0%)	14 (70.0%)	14 (28.0%)
Grade 2	9 (30.0%)	6 (30.0%)	15 (30.0%)
Grade 3	13 (43.3%)	0 (0.0%)	13 (26.0%)
Grade 4	3 (10.0%)	0 (0.0%)	3 (6.0%)
Grade 5	4 (13.3%)	0 (0.0%)	4 (8.0%)
Grade 6	1 (3.3%)	0 (0.0%)	1 (2.0%)
Total	30 100.0%)	20 100.0%)	50 (100.0%)

After exercise, 9 cases out of the 30 were with dyspnoea with Borg scale Grade 2.

- 13 were with Grade 3.

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- 3 were with Grade 4.
- 4 were with Grade 5.
- 1 case was with dyspnea with Borg scale Grade 6.
- Out of the 20 controls, 14 were with Borg scale Grade 1 and 6 were with org scale Grade 2.

FEV1/FVC

The mean FEV1/FVC in the case group is 63.37 where, as the mean FEV1/FVC in the Control group is 87.50.

Table 10: FEV1/FVC in the study

FEV1/FVC	Group	
	Case	Control
Mean (SD)	63.37 (4.15)	87.50 (4.20)
Median (IQR)	63.5 (61-67)	86 (84.75-90)
Range	54-69	82-97

Comparison of the 2 Subgroups in terms of FEV1 (%)

The mean FEV1 in the case group is 86.3 where, as the mean FEV1 in the control group is 86.3

Table 11: FEV1 in the study

FEV1 (%)	Group	
	Case	Control
Mean (SD)	86.30 (3.93)	86.30 (4.17)
Median (IQR)	85.5 (84-89)	85.5 (83.75-87.5)
Range	81-97	80-95

Forced expiratory time

The mean forced expiratory time in cases is 5.3sec and the median forced expiratory time is 5 sec with a range between 4-6 sec.

Table 12: Fet in the study

FET (s)	Case
Mean (SD)	5.33 (0.71)
Median (IQR)	5 (5-6)
Range	4-6

Maximum Tolerated Watts

Maximum tolerated dose in cases was 36 watts and the maximum tolerated dose in controls was 45.2 watts.

Table 13: Maximum tolerated watts cases and controls

Maximum Tolerated Watts	Group	
	Case	Control
Mean (SD)	36.17 (5.97)	45.25 (1.12)
Median (IQR)	35 (35-40)	45 (45-45)
Range	25 – 45	45 – 50

Comparison in Terms of Heart Rate (BPM) (Before Exercise)

The mean heart rate in cases is 73.6and in controls the mean heart rate is 79.30.the median heart rate in cases is 74 beats per minute where as in contrils the median herat rate is 81 beats per minute.

Comparison in Terms of Respiratory Rate (After Exercise)

The mean change in respiratory rate in cases is 24 perminute and in controls 20 breaths per minute. The median respiratory rate in cases is 24 per minute and in controls 21 per minute.

Comparison in terms of change in respiratory rates

The mean change in exercise before and after exercise in cases is 8 per minute

Inspitaratory capacity in the study

Inspiratory Capacity (L) (Before Exercise)

The mean inspiratory capacity in cases is 2.96 the mean inspiratory capacity in controls was 2.97 The median inspiratory capacity in cases is 2.98 watts and median inspiratory capacity in controls is 2.95.

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Inspiratory Capacity (L) (After Exercise)
The mean inspiratory capacity in cases is 2.4L and in controls the median inspiratory capacity is 2.96 L. The median inspiratory capacity in cases is 2.45 L and median inspiratory capacity in controls is 2.94 L

Table 14: Inspiratory capacity (before and after exercise)

Inspratory Capacity (L)	Group			
	Case		Control	
	Mean	Median	Mean	Median
Before Exercise	2.96	2.98	2.97	2.95
After Exercise	2.40	2.45	2.96	2.94
Absolute Change	0.56	0.54	0.01	0.01
Percent Change	18.9%	18.5%	0.3%	0.3%

Table 15: Comparision of cases and controls in terms of heart rate

Heart Rate (BPM)	Group			
	Case		Control	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Before Exercise	73.67	74.00	79.30	81.00
After Exercise	95.27	96.00	95.65	97.00
Absolute Change	21.60	24.00	16.35	6.50
Percent Change	29.9%	31.6%	20.9%	19.3%

Comparison in Terms of Heart Rate (BPM) (After Exercise)
The mean heart rate in cases is 95.27 where as in controlsis 95 beats per minute. The median heart rate in cases is 96 and median is 97 beats per minute.

Comparison terms of change in heart rate
The mean change in heart rate in cases after exercise is 21 beats per minute and the mean change in heart rate is 16.3 beats per minute. The median heart rate is 24 beats per minute in cases and 16 beats per minute in controls**.**

Comparison in terms of SpO2 (%) before exercise
The mean spo2 in cases is 97%.the mean spo2 in controls is 97%. The median Spo_2 in cases and controls is 98%.

Table 16: Comparision of spo2 before and after exercise

SpO2 (%)	Group			
	Case		Control	
	Mean	Median	Mean	Median
Before Exercise	97.50	98.00	97.85	98.00
After Exercise	97.23	98.00	96.50	97.00
Absolute Change	0.27	0.00	1.35	1.00
Percent Change	0.2%	0.0%	1.4%	1.0%

Comparison in terms of SpO2 (%) after exercise
The mean Spo_2 after exercise is 97% in cases and 96% in controls. The median spo2 in cases is 98% and in controls 97%

Comparison in Terms of Respiratory Rate) (Before Exercise)
The mean respiratory rate in cases is 15 per minute. The mean respiratory rate in controls is 14 beats per minute. The median respiratory rate in cases is 16 per minute and in controls is 14 beats per minute.

Table 17: Comparision of cases and controls in terms of respiratory rate

Respiratory Rate (CPM)	Group			
	Case		Control	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Before Exercise	15.40	16.00	14.50	14.00
After Exercise	24.27	24.00	20.65	21.00
Absolute Change	8.87	9.50	6.15	6.00
Percent Change	60.0%	59.8%	42.6%	43.3%

Discussion
An established technique for assessing dyspnea and ventilatory abnormalities is cardiopulmonary

exercise testing. It is frequently used as both a primary and secondary end point in clinical trials because inspiratory capacity (IC) offers useful information on the ventilatory response to exercise. For COPD patients, resting IC is a separate risk factor for mortality and acute exacerbation. It has strong relationships with several critical outcome parameters, including peak oxygen uptake and FEV1.
The GOLD guidelines for mild COPD were used to define the 30 cases in the current study, which also included 20 controls with similar ages and sexes. The cases includes both smokers and nonsmokers. Whereas the controls were nonsmokers. The main aim of the present study is to measure inspiratory capacity by doing spirometry before and after exercise in cases and to compare the same with controls. The following observations were made in the present study.

Age distribution
In the present study
The mean age in the case group is 39.9yrs where, as the mean age of control group is 39.3yrs. The median age in the case group is 38.5 yrs. The median age in the control group is 39.5 yrs. The age in the case group range from 28-55 yrs. The age in the control group range from 27-50 yrs. There was no significant difference between the two groups in terms of age.

Table 18: Age and inspiratory capacity

Group 1	≤40	19.2%
Group 2	40-50	20.1%
Group 3	≥50	15%

- The change in inspiratory capacity after exercise in age group less than 40 years is 19.2%
- The change in inspiratory capacity after exercise in age group between 40-50 years is 20.1%.
- The change in inspiratory capacity after exercise in age group greater than 50 is 15%
- It can be concluded that as the age increases there is decrease in the inspiratory capacity after exercise.

Gashaw Garedew *et al.* conducted a cross-sectional study in 2019 on the prevalence of chronic obstructive pulmonary disease and its risk factors in adults. According to this study, a high prevalence of COPD was significantly associated with being older (50 years and older). Participants' ages ranged from 30 to 75 years, with the mean being 39.15 years. According to the study, the frequency of COPD tends to rise with advancing years, and getting older is thought to increase the risk of developing COPD. The higher exposure to risk factors and physiologic aging-related decline in respiratory function, which starts around the age of 30 to 40, may be the causes of the association between COPD and old age [10].
The present study correlated with the above study in terms of age.

Gender distribution
In the present study
Males were more affected than females. The study included 76% males in cases and 75% males in controls. Women were under represented in the present study due to inadequate diagnosis. As mild COPD is a disease with mild or no symptoms. Most of the females generally do not turn up to the hospital with such mild symptoms. Females included in the study are over 35 years of age.

Table 19: Gender and inspiratory capacity

Group 1	Males	21%
Group 2	Females	13.42%

There was no significant difference between the two groups in terms of gender distribution.
- The mean change in inspiratory capacity in females is 13.2%. The mean change in inspiratory capacity in males is 21%.
- The change in inspiratory capacity after exercise in males is greater in males than females.

Does the gender really matter in COPD? Was the title of a 2011 study on chronic obstructive pulmonary disease by N.K. Jain *et al.* According to the article, indoor air pollution, particularly that from biomass fuel, may play a significant role in the development of COPD in women. The effect of gender on the expression of COPD has received less attention than the impact of tobacco smoke. Which had 29.% females and 70.2% males.
In contrast to females, who were more likely to be exposed to smoke from burning biomass fuel, males were more likely to be exposed to tobacco smoke through beedi smoking. The study found that there are gender-related differences in COPD patients. Early detection of COPD in females will be aided by knowledge of these variations in etiological agent and clinical picture. In many clinical trials, women have been underrepresented, which could lead to a poor diagnosis [10]. Regarding the gender distribution,

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the two studies were correlated.

BMI and COPD
In the present study
The mean BMI in the case group was 24.85. The mean BMI in the control group was 23.44. The median of BMI in the case group was 24.25. The median BMI in the control group was 22.75. The BMI in the cases ranged from 19.6 - 31.2. The BMI in the control group ranged from 21.9-28.

In cases
- 36.7% of the participants in the group had BMI between 23.0-24.9 Kg/m2.
- 20.0% of the participants in the group had BMI between 25.0-29.9 Kg/m2.
- 13.3% of the participants in the group had BMI between 30.0-34.9 Kg/m2.

In controls
- 55.0% of the participants in the group had [BMI: 18.5-22.9 Kg/m2].
- 30.0% of the participants in the group had BMI between 23.0-24.9 Kg/m2.
- 15.0% of the participants in the group had BMI between 25.0-29.9 Kg/m2.
- There was no significant difference between the groups in terms of BMI.
- **Group 1:** The fall in inspiratory capacity after exercise is 17.3%.
- **Group 2:** The fall in inspiratory capacity after exercise is 18.6%.
- **Group 3:** The fall in inspiratory capacity after exercise is 38.5%.

As the BMI increases, there is increase in the rate of fall in inspiratory capacity after exercise.

Table 20: BMI and inspiratory capacity

	BMI	% Fall in IC
Group 1	18.5-24.9	17.3%
Group 2	30-40	18.6%
Group 3	≥40	38.5%

Zhenchao Wu conducted a study in 2018 on body mass index in patients with chronic obstructive pulmonary disease, The study was a retrospective study, and the study included 77% males and among them 57% were smokers. All cases were classified in to 4 groups, group 1 underweight with BMI less than 17.4, group 2 as normal weight with BMI between 17.54-22.12, group 3 as over weight –BMI between 22.12-27 and group 4 as obesity BMI more than 31.25. The study was conducted for a period of 2 years. The objective of the study was to analyse the association between BMI and pulmonary function.
The study's findings showed that as BMI levels rose, peak expiratory flow and forced expiratory volume in one second (FEV1) values also rose. According to the study's findings, as BMI rose, pulmonary function improved while inflammation levels and exacerbation frequency fell. The prognosis of COPD patients can be predicted using their BMI [11].
The present study correlated with the above mentioned study.

Cough in the study
Present study
In the current study, cough was present in 33.3% of cases, with the remaining cases being asymptomatic. No one in the control group had a cough. Chronic cough and sputum production are extremely common in COPD patients, and they are a strong indicator of the disease's progression, exacerbations, and hospitalization, according to a study on the subject done in 2010. This symptom may be used to identify patients who are at risk for clinical deterioration and serve as an indicator of inflammation [12]. The two studies- The one before this one and the one before that - correlate.
An investigation on the impact of cough and phlegm in COPD carried out in 2017 by Radmila Choate *et al.* The study's primary goal was to calculate the prevalence and severity of cough and phlegm in patients, as well as the impact and burden these conditions have on those with COPD diagnoses. A moderate to severe cough or phlegm level affected three-fourths of the patients. The study's findings, which are consistent with the findings of the present study, are that higher levels of phlegm are linked to worse clinical and quality of life outcomes.

Smoking and inspiratory capacity
In the present study 73% of the cases were smokers and the rest 26.7% of the cases were nonsmokers. Where as in the controls all the subjects were nonsmokers.
- There was a significant difference between the various groups in terms of distribution of Smoking.

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Table 21: Moking and inspiratory capacity

Smokers	20.78%
Nonsmokers	14.2%

- The rate of fall in inspiratory capacity after exercise in smokers is 20.78%
- The rate of fall in inspiratory capacity after exercise in nonsmokers is 14.2%.

The rate of fall in inspiratory capacity after exercise is greater in smokers than nonsmokers.

A study conducted by Yoshihiro kitahara *et al.*, on cigarette smoking decreases the dynamic inspiratory capacity during sub maximal exercise [13] which is correlated with the present study.
Another study by Jordi Olloquequi in 2018 compared the effects of tobacco smoke and biomass exposure on COPD in 49 COPD patients and found a synergistic detrimental effect, which was related to the present study [14].
A 2017 study by Juon Antonio Riesco *et al.* on the distribution of the COPD phenotype and its effect on prognostic variables Patients with a diagnosis of COPD participated in the observational, cross-sectional, multicenter study. Higher grade dyspnoea was linked to active smoking. According to the study's findings, active smoking is more prevalent with exacerbator types and seems to have an impact on severity and quality of life [15].
The present study correlated with the above study

Pack years and COPD
In the present study

- 56.7% of the cases had biomass exposure where as 43.3% of the cases did not have biomass fuel exposure. In controls 30% of the subjects had exposure to biomass fuel.

A study done on smoking duration alone provides a stronger risk for COPD development and progression by Surya P. Bhatt.*et al.* The study was a cross sectional study done in 2018 on current and former smokers. The study concluded that smoking duration alone provides the strong risk estimates of COPD than the composite index of pack years [16].
Laura Miranda Oliveria Caram *et al.* conducted a study on smoking and early COPD as independent predictors of body composition and health status. The study included 32 smokers with a smoking history longer than 10 pack years, 32 people with mild to moderate COPD, and 32 nonsmokers. According to the study's findings, early COPD patients and smokers have poorer health and exercise capacity. Body composition, exercise capacity, and health status are all negatively impacted by smoking and early COPD [17].
The present study correlates well with the above mentioned study.

Table 22: Pack years and inspiratory capacity

Group 1	≤10	18.07
Group 2	10-15	19.4
Group 3	≥15	22.37

- The rate of fall in inspiratory capacity after exercise in group 1 is 18.07%
- The rate of fall in inspiratory capacity after exercise in group 2 is 19.4%
- The rate of fall in inspiratory capacity after exercise in group 3 is 22.37%.
- As the pack years increase, there is increase in the rate of fall inspiratory capacity after exercise.

BIOMASS exposure and COPD:
In the present study

- 56.7% of the cases had biomass exposure where as 43.3% of the cases did not have biomass fuel exposure. In controls 30% of the subjects had exposure to biomass fuel.
- There was no significant difference between the various groups in terms of distribution of Second Hand Smoke Exposure.

According to a 2018 study by Adama Sana on COPD and exposure to biomass fuel in women, which is a systemic review and meta-analysis to determine the association between COPD and exposure to biomass fuel in women, biomass smoke exposure is linked to COPD in both rural and urban women. The study confirms that exposure to biomass smoke is linked to COPD in women. Cooking energy and cooking stoves need to get more attention because it has been shown that exposure to biomass smoke causes COPD in both case-control and cross-sectional groups [18].

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FET in COPD

In the present study the mean forced expiratory time was 5.33 sec with FET range between 4-6 sec in cases. Forced expiratory time is increased in cases.

Ashutosh nath agarwal *et al.* conducted a study on diagnostic characteristics to substantiate the utility of FET the study was done in 70 patients with airflow obstruction and 70 controls with normal spirometry. In his study he stated that median FET was longer in patients with mild airflow obstruction. At a threshold of 5 seconds FET had higher sensitivity and reasonable specificity in patients with airflow obstruction [17].

The present study comparable with the above mentioned study.

Borg scale in COPD

In the present study

There was a significant difference between the various groups in terms of distribution of Borg Scale (After Exercise)

- 0% of the participants in the Case group had Borg Scale Grade 1.
- 30% of the participants in the Case group had Borg Scale Grade 2
- 43% of the participants in the Case group had Borg Scale Grade 3.
- 10% of the participants in the Case group had Borg Scale Grade 4.
- 13% of the participants in the Case group had Borg Scale Grade 5.
- 3% of the participants in the case group had Borg Scale Grade 6.
- 70% of the participants in the Control group had Borg Scale Grade 0.
- 30% of the participants in the Control group had Borg Scale Grade.

Table 23: Post-test Borg scale and inspiratory capacity

Group 1	≤3	16.5%
Group 2	3-5	19.5%
Group 3	≥5	23.4%

Post-test Borg scale and inspiratory capacity

- Group1 the rate of fall on inspiratory capacity is 16.5%
- Group 2 the rate of fall in inspiratory capacity is 19.5%
- Group 3, the rate of fall in inspiratory capacity is 23.4%
- As the borg scale grade increases after exercise there is increase in the rate of fall in inspiratory capacity.

A study conducted by Karla R Kendrick IN 2000 usefulness of modified 0 to 10 borg scale in assessing the degree of dyspnoea in patients with COPD. The study concluded that the modified borg scale is a valid and reliable assessment tool for dyspnoea. The study showed that modified borg scale correlated well with other clinical parameters and it could be useful when assessing and monitoring outcomes in patients with COPD [19], which correlated well with the above mentioned study.

Respiratory rate

In the present study

- The mean respiratory rate in cases before exercise was 15.40. And the mean respiratory rate after exercise was 24.27.
- Where as in controls the mean respiratory rate in cases was 14.50 before exercise and 20.65 after exercise. The median in cases and controls is 14 and 21 respectively.
- There was a significant difference in the change in respiratory rate between cases and controls.

Spo2 in COPD

In the present study

- The mean saturation in patients with mild COPD is 97.5 before exercise and in controls the mean saturation was 97.8.
- The mean saturation in cases after the exercise test was 97.23 and the mean saturation in controls after exercise was 96.5.
- There is no much change in the saturation levels between cases and controls.
- 4 out of 30 cases had drop in saturation levels the cardio pulmonary exercise testing.

There was no significant difference in the trend of SpO2 (%) in both the group.

A study conducted by Hadelli on the predictors of oxygen de saturation during sub maximal exercise in 2001. The objective of the study is to determine the oxygen de saturation during sub maximal exercise in patients with chronic lung disease. The study is a retrospective study. Subjects included in the study are

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more than 35 years of age. Oxygen saturation drop greater than 4 is considered abnormal. The conclusion of the study was that DLCO was one of the predictor for the risk of oxygen de saturation in COPD. In patients with low DLCO there was a risk of de saturation during sub maximal exercise (20).

Heart rate
In the present study
- The mean heart rate in the case group was 95.27. The mean Heart Rate) in the control group was 95.65. The median heart rate in the case group was 96 (90-100).
- The median heart rate (after exercise) in the control group was 97. The heart rate in the case ranged from 68 - 110. The heart rate in the controls ranged from 84 - 114.

There was no significant difference between the groups in terms of heart rate
A 2005 study by Miriam Lacasse on the relationship between mortality from chronic obstructive pulmonary disease and post-exercise heart rate recovery. Since chronic obstructive pulmonary disease is linked to cardiac autonomic dysfunction, the study investigated whether COPD patients have lower heart rates than healthy individuals and explored whether a delay in heart rate is linked to a higher mortality rate in the condition. Following an exercise test, the heart rate was recorded during peak exercise and for one minute afterward. Abnormal HRR 14 beats is a wrong predictor of mortality in COPD. The difference between the two is known as heart rate recovery (HRR). The study's findings were that patients with low heart rate recovery (HRR) compared to healthy controls have a worse prognosis when exhibiting abnormal heart rate recovery [21].

FEV1/FVC
The case group's average FEV1/FVC ratio was 63.37. The control group's mean FEV1/FVC value was 87.50. The case group's median FEV1/FVC value was 63.5. The control group's median FEV1/FVC value was 86. In the cases, the FEV1/FVC ranged from 54 to 69. The FEV1/FVC: Control group had values between 82 and 97.
The mean FEV1/FVC was highest in the Control group, with a significant difference between the 2 groups in terms of FEV1/FVC.

FVC
The mean FVC in the present study is 86.3 with the range between 81-97. The mean FVC in controls was 86.3 with the range between 80-95.

Cardiopulmonary exercise testing

Table 24: Maximum tolerated watts cases and controls

Maximum Tolerated Watts	Group	
	Case	Control
Mean (SD)	36.17 (5.97)	45.25 (1.12)
Median (IQR)	35 (35-40)	45 (45-45)
Range	25 – 45	45 – 50

Watts at which subjects stopped exercise
- The mean of Maximum Tolerated Watts in the: Case group was 36.17. The mean of Maximum Tolerated Watts in the Control group was 45.25.
- The median of Maximum Tolerated Watts in the Case group was 35. The median of Maximum Tolerated Watts in the Control group was 45.
- The Maximum Tolerated Watts in the Case ranged from 25 - 45. The Maximum Tolerated Watts in the: Control group ranged from 45 - 50.
- Cases couldn’t tolerate higher watts and stopped exercise earlier. Few cases stopped exercise due to lower limb muscle muscle fatigue. Few cases stopped exercise due to shortness of breath.very few cases continued exercise to 40 watts.
- 2 controls out of the 20 controls stopped exercise due to muscle fatigue where, as rest of the controls continues exercise till end of 10 mins up to 45 watts.
- There was a significant difference between the 2 groups in terms of Maximum Tolerated Watts), with the median Maximum Tolerated Watts being highest in the Group: Control group.

In the present study
- 5 out of 30 patients stopped exercise due to lower limb muscle fatigue.
- Most of the patients stopped exercise after about 8 mins of exercise due to shortness of breath.
- 14 patients out of the 30 continued cycle ergometry till 10 minutes.
- The reason for stopping exercise may be due to shortness of breath is due to dynamic hyperinflation

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- There might be skeletal muscle dysfunction and initiation of exercise training programs has been shown to improve muscle function.

Table 25: Smoking and tolerated watts

Smokers	37.1 watts
Nonsmokers	40 watts

Smokers tolerated a mean dose of 37.1 watts where, as the nonsmokers tolerated a mean dose of 40 watts By this we can conclude that the maximum tolerated dose was less for smokers than nonsmokers.

Inspiratory capacity

Table 26: Inspiratory capacity before and after exercise

Inspratory Capacity (L)	**Group**			
	Case		**Control**	
	Mean	**Median**	**Mean**	**Median**
Before Exercise	2.96	2.98	2.97	2.95
After Exercise	2.40	2.45	2.96	2.94
Absolute Change	0.56	0.54	0.01	0.01
Percent Change	18.9%	18.5%	0.3%	0.3%

Inspiratory capacity is the maximum volume of air that can be inspired after a quiet expiration to end expiratory lung volume. The inspiratory capacity is an indirect measure of lung hyper inflation

In the present study

- **Before exercise**

The mean Inspiratory capacity in patients with mild COPD was 2.96 with the range between 2.24-3.78.In controls the mean Inspiratory capacity was 2.95 with the range between 2.76-3.2. The median Inspiratory Capacity (L) in the case group was 2.98. The median Insipiratory capacity in the control group was 2.95. There was no significant difference between the groups in terms of Inspiratory capacity before exercise.

- **After exercise**

The mean Inspiratory capacity (L) in the Case group was 2.40. The mean Inspiratory capacity (L) in the control group was 2.96. The median Inspiratory Capacity in the case group was 2.45. The median Inspiratory capacity in the control group was 2.94. The Inspiratory capacity cases ranged from 1.09 - 3.1. The Inspiratory Capacity (L) in the control ranged from 2.65 - 3.27.

- There was a significant difference between the 2 groups in terms of Inspiratory Capacity (After Exercise) with the median Inspiratory capacity after exercise being highest in the Control group
- The rate of fall in inspiratory capacity after exercise is greater in females when compared to males.
- As the age increases the rate of fall in inspiratory capacity after exercise increases with greatest fall in the age group greater than 40 years.
- As the BMI increases the rate of fall in inspiratory capacity increases after exercise.
- Greater fall in inspiratory capacity after exercise is more in smokers with higher pack years than nonsmokers.
- There is a greater fall in inspiratory capacity after exercise in those with higher post-test borg scale.

The fall in the inspiratory capacity before and after exercise is due to the dynamic hyperinflation. Dynamic hyperinflation plays an important role in the development of exercise limitation. Both static and dynamic hyperinflation has been seen in COPD. It is the transient increase in volume above the relaxation volume. During exercise dynamic hyperinflation which attenuates expiratory flow limitation and induces the functional weakness of the diaphragm. It also causes more rapid shallow breathing and progressive reduction in lung compliance. These events can explain exercise intolerance.

Expiratory flow limitation is main hallmark of the disease. The most prominent and distressing symptom is the breathlessness.

The primary factor limiting exercise performance in COPD is dynamic hyperinflation during exercise, according to a 2008 study by Denis E. O. Donnel. In patients with mild COPD, the combination of increased ventilator requirements and abnormal dynamic ventilator mechanics stresses the already depleted cardiopulmonary reserves. It has been discovered that low inspiratory capacity and reduced peak oxygen uptake correlate well, supporting the idea that mechanical factors play a role in exercise limitation. Additionally, the study included patients with moderate to severe COPD. The average reduction in IC from resting value to peak exercise was 20% [22].

A study conducted by O Dias *et al.* in 2000 regarding the role of inspiratory capacity on exercise tolerance in COPD in which 52 patients were included in the study and concluded that inspiratory capacity and FEV1/FVC as only significant contributors to exercise tolerance [23]. The present study correlated well to the above-mentioned studies.

Conclusions

The results of this study led to the following conclusions: People with mild COPD exhibit a notable reduction in their ability to inhale. The rate of fall in inspiratory capacity following exercise rises as age does. Smokers experience a greater decline in inspiratory capacity following exercise than non-smokers, with those who have smoked the most packs per year experiencing the greatest decline. More work was tolerated to a lower extent by smokers than by nonsmokers. Even in cases of mild COPD, exercise is significantly limited. Thus, early intervention and appropriate treatment raise the threshold for exercise and improve life quality.

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Conflict of interest

Non

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