The benefits of early pulmonary rehabilitation with incentive spirometer among chronic obstructive pulmonary disease patients with exacerbation of chronic obstructive pulmonary disease

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ABSTRACT

Introduction: Inspiratory muscle dysfunction is prevalent in chronic obstructive pulmonary disease (COPD). This study aimed to compare the benefits of adding volume incentive spirometry (VIS) to active-cycle-breathing technique (ACBT) and ground-based walking (GBW) training in patients hospitalised for COPD exacerbations. The objectives were to evaluate the impact of early initiation of VIS on respiratory muscle strength, measured by maximum inspiratory pressure (MIP), maximum expiratory pressure (MEP) and the 6-minute walk test (6-MWT), as well as on symptoms, as assessed by the COPD assessment test (CAT) score.

Materials and Methods: This randomised, prospective study was conducted among COPD subjects admitted with exacerbation between June 2021 and August 2022. Subjects were randomly assigned to either the VIS (interventional group) or the control group. Baseline assessments, including spirometry, MIP, CAT score, and the 6-minute walk test (6MWT), were performed. Both groups commenced active cycle of breathing techniques (ACBT) and ground-based walking (GBW) training within 72 hours of admission, with daily sessions involving three repetitions of each phase to complete one cycle, repeated three times daily. The intervention group received VIS. Upon discharge, subjects were provided with a diary and instructed to continue a home-based pulmonary exercise regimen, performed for at least 15 minutes per day, 3 days a week, with compliance monitored through weekly phone calls. At the 4-week follow-up, repeat assessments of spirometry, MIP, maximal expiratory pressure (MEP), CAT score and 6MWT were conducted to evaluate the outcomes.

Results: A total of 34 subjects with a median age of 68 years (interquartile range [IQR] 65–74.3 years). The cohort predominantly males (32 subjects, 94%). The distribution of disease severity was as follows: GOLD 2 in 15 subjects (44%) and GOLD 3 in 14 subjects (41%). Additionally, 17 subjects (50%) had experienced three or more exacerbations in the preceding year. The majority of patients (29 out of 34, 85%) had a length of stay of less than 7 days. In the interventional group, the median MIP improved from 50 cm H2O (IQR 40.5–70.5) to 59 cm H2O (IQR 39–76.5), though this was not statistically significant (p = 0.407). The control group saw an improvement from 58 cm H2O (IQR 36.5–85) to 60 cm H2O (IQR 33–88), also not statistically significant (p = 0.112). The 6MWT distance improved in the interventional group from 220 meters (IQR 118–275) to 260 meters (IQR 195–327) (p = 0.002) and in the control group from 250 meters (IQR 144–294) to 280 meters (IQR 213–359.5) (p = 0.001). The median CAT score decreased significantly in the interventional group from 22 (IQR 16–28) to 11 (IQR 7.5–13) (p < 0.001) and in the control group from 21 (IQR 14–24.5) to 10 (IQR 8–12.5) (p < 0.001).

Conclusion: Early initiation of pulmonary rehabilitation in patients with acute exacerbations, characterised by poor muscle strength and a history of exacerbations, resulted in significant improvements in patient-reported symptoms and 6MWT outcomes. Although there was only a numerical improvement in MIP and MEP, the intervention did not extend the length of hospital stay, highlighting its safety and efficacy in the acute care setting.

KEYWORDS:
COPD, pulmonary rehabilitation, ACBT, incentive spirometer

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a preventable and treatable disease characterised by persistent airflow limitation and respiratory symptoms. It is usually caused by significant exposure to tobacco smoking and pollutants. Host factors that may predispose to the development of COPD include genetic abnormalities, abnormal lung development and ageing.[1]

COPD exacerbations are episodes of worsening symptoms associated with increased airway inflammation and physiological changes. Symptom recovery generally improves over the first 14 days after an exacerbation of COPD; however, it varies between studies and individuals.[2]

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Systematic review has shown that prior exacerbation history is an important predictor for future moderate to severe exacerbations.[3]

Patients with COPD are frequently disabled because of dyspnoea as a result of a decreased capacity of the respiratory muscles. In stable COPD, respiratory muscles, in particular the inspiratory muscle function, are altered. Following an exacerbation of COPD, there is a decrease in external intercostal muscle strength and hyperinflation of the lungs, resulting in a decline in forced expiratory volume at 1 second (FEV1) and maximal inspiratory pressure (MIP).[4]

MIP is a non-invasive parameter used to assess respiratory muscle strength. In the early stages of COPD, MIP declines with the reduction of diaphragmatic contractility, and in later stages, further reduction of MIP is caused by hyperinflation of the lungs and reduced inspiratory muscle strength.[5] This decline is important as MIP appears to be a distinct predictor of survival.

Pulmonary rehabilitation (PR) is an accepted non-pharmacological treatment for COPD, proven to improve quality of life and exercise capacity.[6] Volume-oriented incentive spirometer (VIS) is a device used in PR that measures the volume of inspired air to assess patient's inspiratory effort with visual feedback. It has been shown to be effective in improving lung function and functional capacity.[7] Hosseini et al. reported a significant increase in MIP in moderate COPD patients admitted with an exacerbation following 4-weeks of VIS training.[8] Faster improvement in physical performance with early PR has been seen after acute exacerbation of COPD.[9]

The benefits of early inpatient PR with VIS during peri and post-exacerbation of COPD have not been widely studied. The objectives were to evaluate the impact of early initiation of VIS on respiratory muscle strength, measured by MIP, maximum expiratory pressure (MEP) and the 6-minute walk test (6-MWT), as well as on symptoms, as assessed by the COPD assessment test (CAT) score.

MATERIALS AND METHODS

Study Design and Participants

This was a randomised, prospective interventional single-centre study of COPD patients admitted with exacerbation to Universiti Kebangsaan Malaysia Medical Centre (UKMMC), conducted between June 2021 and August 2022. The Research Ethics Committee, Universiti Kebangsaan Malaysia, FF-2020-444 approved the study protocol.

We included COPD patients with a documented spirometry result with an FEV1/FVC ratio of less than 70%, aged more than 40 years who were admitted with a diagnosis of acute exacerbation of COPD (AECOPD). AECOPD was defined as sustained worsening of a patient's baseline respiratory symptoms, lasting for at least 48 hours and requiring the addition or increase of bronchodilators, corticosteroids or antibiotics.

Patients were excluded if they had a diagnosis of bronchial asthma, were on long-term oxygen therapy (LTOT), or had uncontrolled hypertension. Additional exclusion criteria included unstable cardiac conditions such as congestive heart failure, recurrent pneumothorax, neuromuscular disorders, cerebrovascular accident with a modified Rankin Scale (mRS) score >3, prior completion of pulmonary rehabilitation, recent eye surgery, inability to tolerate upright sitting, cognitive impairments that precluded comprehension of instructions, or the presence of pain that interfered with the performance of forceful breathing manoeuvres.

Subjects were assigned to either the intervention group (VIS) or the control group (non-VIS) using block randomisation with a 1:1 ratio. Both groups received the same standard interventions, including active cycle breathing technique (ACBT) and ground-based walking training (GBW). Blinding of the investigators was not feasible due to the distinct nature of the intervention. Consequently, the investigators were not blinded during the analysis.

Subjects were recruited within 72 hours of admission. Upon admission, all participants underwent laboratory screening, and baseline demographic data were collected. A review of exacerbation history, current medications and medical records, including the number of hospitalisations and emergency department visits, was conducted.

Baseline spirometry, including pre-bronchodilator FEV1/FVC, MIP, and MEP, was performed by a trained technician using the Plethysmography Bodybox System (CareFusion) model VMAX E22. According to ATS criteria, subjects were required to perform the spirometry test by exhaling for at least 6 seconds, with a minimum of three attempts and a maximum of eight, depending on test quality. Results were deemed acceptable if the difference between the two best readings was less than 5% and 150 mL. Additionally, subjects completed a COVID-19 antigen rapid test (RTK-Ag) within 72 hours prior to the procedure. Technicians adhered to level three personal protective equipment (PPE) protocols, and disposable, single-patient mouthpieces were used to minimise infection transmission.

The CAT was utilised to evaluate the impact of COPD on health status. This instrument comprises eight domains, with a total score ranging from 0 to 40. The scores are categorised into four levels: low, medium, high and very high. The CAT is a single-dimensional tool available in multiple languages. Depending on the subject's language preference, the questionnaire was administered in Malay, English or Chinese.

6MWT is a simple, self-paced walking test to assess the level of functional exercise capacity. It was done by a trained physiotherapist. The walking track was a flat, hard-surfaced, continuous point-to-point 15-meter tract. Portable pulse oximetry was used to monitor patients' oxygen saturation throughout the test, and it was recorded every minute. Blood pressure was recorded pre-and post-test.

All subjects were required to perform both active cycle of breathing technique (ACBT) and ground-based walking (GBW). ACBT is a breathing technique that combines three different phases of breathing techniques to loosen airway secretions. It involves breathing control (tidal breathing

using the lower chest with shoulders and upper chest relax), chest expansion (breathe in deeply and hold the breath for 5-seconds followed by passive relaxed expiration) exercises and forced expiration technique (huffing -inhaling and active exhaling). Subjects were required to repeat each phase 3 times to complete one cycle of ACBT and to do three cycles at different times in a day. Subjects were trained at least twice during admission to ensure their understanding of the steps and techniques of ACBT. The teach-back method was employed during one-to-one sessions to confirm the effectiveness of the interventions used.

GBW training was conducted by a trained physiotherapist. Subjects were instructed to walk at their own pace on a flat surface for 15 minutes per day, three times a week. Rest breaks were permitted during the walking sessions if patients experienced shortness of breath, light-headedness, or other intolerable symptoms.

In the interventional group, subjects received VIS in addition to ACBT and GBW training. VIS is a therapeutic tool designed to enhance lung function by promoting deep breathing. It utilises a hand-held device, specifically the B-Spiro 5000 as shown in Fig.1 which includes a low resistance filter and measures inhaled air volume while providing visual feedback. Patients are instructed to sit upright, seal the mouthpiece properly, and breathe in forcefully to maintain the piston between two lines for at least 3 seconds. Subjects were required to perform 15 breaths three times a day. The use of VIS aids in lung expansion, helps prevent complications such as atelectasis and supports overall respiratory health.

All subjects were provided with a diary to document their at-home pulmonary rehabilitation (PR) activities to ensure adherence. Weekly telephone follow-ups were conducted to evaluate symptoms, remind subjects of their PR regimen, and verify diary documentation. At week 4, a comprehensive assessment was performed, including a review of symptoms, and spirometry with MIP, MEP, CAT score, and 6MWT were repeated.

Statistical Analysis

The sample size calculation was performed using Cohen's d Formula of effect size (Cohen 1988). The sample size was based on a study by Goswami et al. using 6MWT pre- and post-forced expiratory techniques in chronic bronchitis patients.10 The calculated sample size was 92 (46 subjects in each group), allowing a 10% drop-out rate. The power of the study was designed at a level of 80%. Enrolment was interrupted by the COVID-19 pandemic in March 2020 when UKMMC became a hybrid hospital accepting COVID-19 cases. This resulted in fewer COPD hospital admissions, which slowed down recruitment. The final sample size was 34, and the last subject was recruited in August 2022.

All statistical analyses were performed using Statistical Package for Social Sciences version 27.0 (SPSS Inc, Chicago, IL, USA). Variables were expressed in median (interquartile) and range. Continuous variables were analysed using the Mann–Whitney U test while comparing the two groups: interventional and non-interventional groups. The categorical data was tested with the Wilcoxon signed-rank test. Spearman's rank correlation coefficient was used to determine the relationship between MIP and FEV1, as well as the CAT score and 6MWT. All p-values were two-sided, and values below 0.05 were considered statistically significant.

RESULTS

A total of 34 participants were randomised into two groups: 17 in the intervention group and 17 in the control group. The study design and CONSORT flow diagram are presented in Figure 2. The demographic and baseline characteristics were similar across the groups (Table I). The median age in the intervention group was 71 years (IQR 65–75), while in the control group it was 67 years (IQR 64.8–73). The participants were predominantly male, accounting for 94% of the group. Ethnic distribution was predominantly Malay (70.6%), followed by Chinese (23.5%) and Indian (5.9%). The majority of participants were ex-smokers (27, 79.4%), with five (14.7%) being active smokers and two (5.9%) passive smokers.

Most subjects, 23 (67.6%), had at least one comorbidity, with nine (26.5%) having two, and seven (20.6%) having three or more comorbidities. The distribution according to GOLD classification was: 15 subjects (44.1%) in GOLD II, 14 (41.2%) in GOLD III, 4 (11.8%) in GOLD IV, and 1 (2.9%) in GOLD I. There was no difference in the number of exacerbations between the groups. Two subjects (5.9%) experienced exacerbations once a year, 15 (44%) had exacerbations twice a year, and 17 (50%) had three or more exacerbations annually.

Seven subjects (20%) did not require any supplemental oxygen. Nasal prongs were needed by 41%, 20% required NIV, 11% used a Venturi mask and only 1(2%) required intubation.

The median baseline MIP was 55 cm H_2O, with the control group exhibiting a baseline MIP of 60 cm H_2O and the intervention group a baseline MIP of 50 cm H_2O. The MEP was 65 cm H_2O, with the control group having a baseline MEP of 64 cm H_2O and the intervention group a baseline MEP of 66 cm H_2O.

There was no difference between the interventional group and control group in baseline MIP and MEP (Table II). MIP showed an improvement in both groups at week 4. In the interventional group, the median baseline MIP was 50 cmH_2O (IQR 40.5–70.5) and 59 cmH_2O (39–76.5) at week 4 (p=0.407). In the control group, the median MIP improved from 58 cmH_2O (36.5–85) to 60 cmH_2O (33–88) (p = 0.112).

Approximately 50% (17) of the participants did not record the interventions in the provided diary. However, follow-up phone calls revealed that they were, in fact, adhering to the prescribed pulmonary rehabilitation regimen.

The median 6MWT distance for the overall study population was 235 meters (IQR 126–282). The addition of VIS significantly improved exercise capacity, increasing from 220 meters (IQR 118–275) to 260 meters (IQR 195–327) (p =

Table I: Demographic and baseline characteristics between Interventional and non-interventional groups (n = 34)

Demographic variables	COPD patients admitted for COPD exacerbation n = 34		U	p-value
	Interventional group n = 17	Control group n = 17		
Age (years)	71(65–75)	67 (64.5–73)	113.5	0.284[a]
BMI (kg/m^2), n (%)				
<18.5	2 (11.8)	3 (17.6)	125.5	0.487[a]
18.5–22.9	4 (23.5)	6 (35.3)		
23–24.9	3 (17.6)	1 (5.9)		
≥25	8 (47.1)	7 (41.2)		
Gender, n (%)				
Male	15 (88.2)	17 (100)	127.5	0.151[a]
Female	2 (11.8)	0 (0)		
Ethnicity, n (%)				
Malay	12 (70.6)	6 (35.5)	88.5	0.033[a]
Chinese	4 (23.5)	7 (41.2)		
Indian	1 (5.9)	3 (17.6)		
Others	0 (0)	1 (5.9)		
Smoking status, n (%)			133	0.574a
Non-smoker	0 (0)	0 (0)		
Active smoker	2 (11.8)	3 (17.6)		
Ex-smoker	13 (76.5)	14 (82.4)		
Passive smoker	2 (11.8)	0 (0)		
Co-morbidities, n (%)				
DM	4 (23.5)	5 (29.4)	136	0.702[a]
HTN	10 (58.8)	7 (41.2)	119	0.311[a]
HPL	7 (41.2)	9 (52.9)	127.5	0.498[a]
IHD	2 (11.8)	3 (17.6)	136	0.633[a]
GOLD stages, n (%)				
1	1 (5.9)	0 (0)	126	0.488[a]
2	8 (47.1)	7 (41.2)		
3	6 (35.3)	8 (47.1)		
4	2 (11.8)	2 (11.8)		
Inhalers, n (%)				
SABA	16(9.4)	17 (100)	136	0.317[a]
LABA	0 (0)	0 (0)	144.5	1.000[a]
SAMA	0 (0)	0 (0)	144.5	1.000[a]
LAMA	4 (23.5)	4 (23.5)	144.5	1.000[a]
SAMA/SABA	1 (5.9)	4 (23.5)	119	0.152[a]
ICS	0 (0)	1(5.9)	136	1.000[a]
LAMA/LABA	13(76.4)	13(76.4)	144.5	0.317[a]
LABA/ICS	2 (11.8)	0 (0)	127.5	0.151[a]
LAMA/LABA/ICS	0 (0)	0 (0)	144.5	1.000[a]
Number of exacerbation past 1 year, n (%)				
1	1 (5.9)	1 (5.9)	104.5	0. 121[a]
2	5 (29.4)	10 (58.8)		
≥3	11 (64.7)	6 (35.3)		
Length of hospital stay (days), n (%)				
<7	14 (82.4)	15 (88.2)	136.5	0.654[a]
7–10	2 (11.8)	1 (5.9)		
≥11	1 (5.9)	1 (5.9)		
Highest oxygen requirement during admission, n (%)				
Room air	1 (5.9)	6 (35.3)	106.5	0.170[a]
Nasal prong	8 (47.1)	6 (35.3)		
Face mask	1 (5.9)	0 (0)		
Venturi mask	3 (17.6)	1 (5.9)		
High flow mask	0 (0)	0 (0)		
NIV**	4 (23.5)	3 (17.6)		
Mechanical ventilation	0 (0)	1 (5.9)		
MIP (cmH_20)	50 (40.5–70.5)	60(33–88)	119.5	0.389[a]
MEP (cmH_20)	66 (43–88)	64(35.5–81)	137	0.796[a]
FEV1 (Liter)	1.28(0.88–1.56)	1.26 (0.84–1.55)	133	0.904[a]
FEV1 (%)	51(36.5–62.5)	48 (39–56)	141	0.962[a]
6MWT				
Distance (meters)	220 (118–275)	250(144–294)	126	0.524[a]
Lowest saturation (%)	92(88–94.5)	92(90.5–94)	121	0.413[a]
CAT Score	22(16–26)	21(24)	137.5	0.809[a]

*DM: Diabetes mellitus, HTN: Hypertension, HPL: Hyperlipidaemia, IHD: Ischemic heart disease:
**NIV: Non-invasive ventilation
a : Mann-Whitney U test; p-value < 0.05 is significant

Table II: Comparison of MIP score, CAT score and 6MWT within interventional and non-interventional group (n = 34)

Variables	Interventional group (n = 17)			Control group (n = 17)		
	Before	After	p-value	Before	After	p-value
MIP (cmH20)	50(40.5–70.5)	59(39–76.5)	0.407	58(36.5–85)	60(33–88)	0.112
MEP (cmH20)	66 (43–88)	69(51.5–77)	0.356	64(35.5–81)	63(50.5–101)	0.014
FEV1 (Litres)	1.28(0.88–1.56)	1.1(0.95–1.71)	0.023	1.26(0.84–1.55)	1.19(0.95–1.74)	0.055
FEV1 (%)	51(36.5–62.5)	57(40.5–68.5)	0.017	48(39–56)	51(39–63.5)	0.044
CAT Score						
6MWT	22(16–26)	11(7.5–13)	<0.001	21(14–24.5)	10(8–12.5)	<0.001
Distance(metres)	220(118–275)	260(195–327)	0.002	250(144–294)	280(213–359.5)	0.001
Lowest SpO_2 (%)	92(88–94.5)	95(91–95)	0.002	92(90.5–94)	95(93.5–96)	0.004

Note: Data are presented as median (IQR) unless otherwise stated.
MIP: Maximal inspiratory pressure, CAT: COPD assessment test, 6-MWT: 6 minutes walking test
a Wilcoxon signed-rank test; p-value < 0.05 is significant

Table III: Association of the mean difference (baseline and at week 4) of MIP, CAT score and 6 MWT between the two groups

Variables	Interventional group	Control group	U	p-value
Δ mean MIP (cmH20)	9.0 (20.0)	5.0 (9.5)	128.0	0.569[a]
Δ mean MEP (cmH20)	5.0 (13.0)	4.0 (12.5)	136.5	0.783[a]
Δ mean FEV1 (Litres)	0.06 (0.14)	0.08 (0.16)	142.5	0.945[a]
Δ mean FEV1(%)	3 (5.5)	3 (7.3)	139.5	0.863[a]
Δ mean CAT Score	–9.0 (6)	–10.0 (8.5)	124.5	0.490[a]
Δ mean 6 MWT				
Distance (metres)	40 (57)	36 (83)	134.0	0.717[a]
Lowest SPo2 (%)	2 (2.5)	3 (3)	121.0	0.413[a]

MIP: Maximal inspiratory pressure, CAT: COPD assessment test, 6 MWT: 6 minutes walk test
a: Mann-Whitney U test; p-value < 0.05 is significant

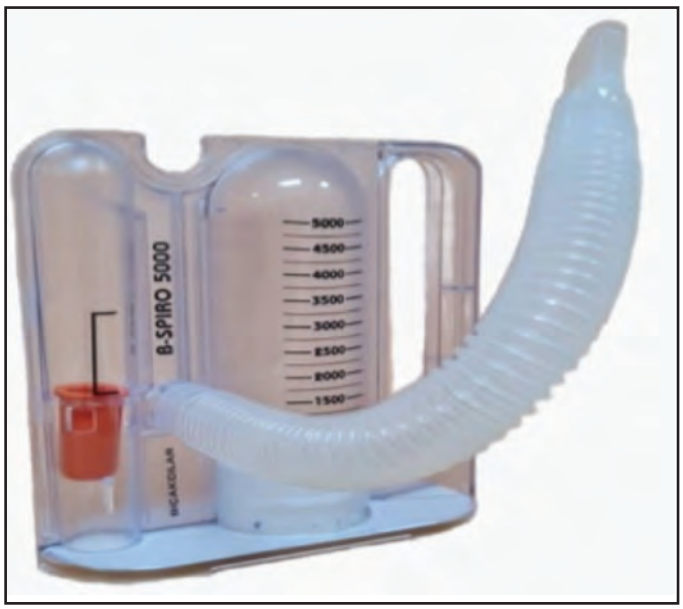

Fig. 1: Volume-oriented (B-Spiro 5000) incentive spirometer.

0.002). This improvement was also observed in the control group, where the distance increased from 250 meters (IQR 144–294) to 280 meters (IQR 213–359.5) (p = 0.001).

The baseline median CAT score for the overall study population was 21.5 (IQR 15.8–25). In the intervention group, the median CAT score was 22 (IQR 16–26) at baseline and decreased to 11 (IQR 7.5–13) at week 4 (p < 0.001). A similar result was seen in the control group: 21 (14–24.5) to 10 (8–12.5) (p = <0.001). Comparison between the two groups in MIP, MEP, FEV1, CAT score and 6MWT is shown in Table III.

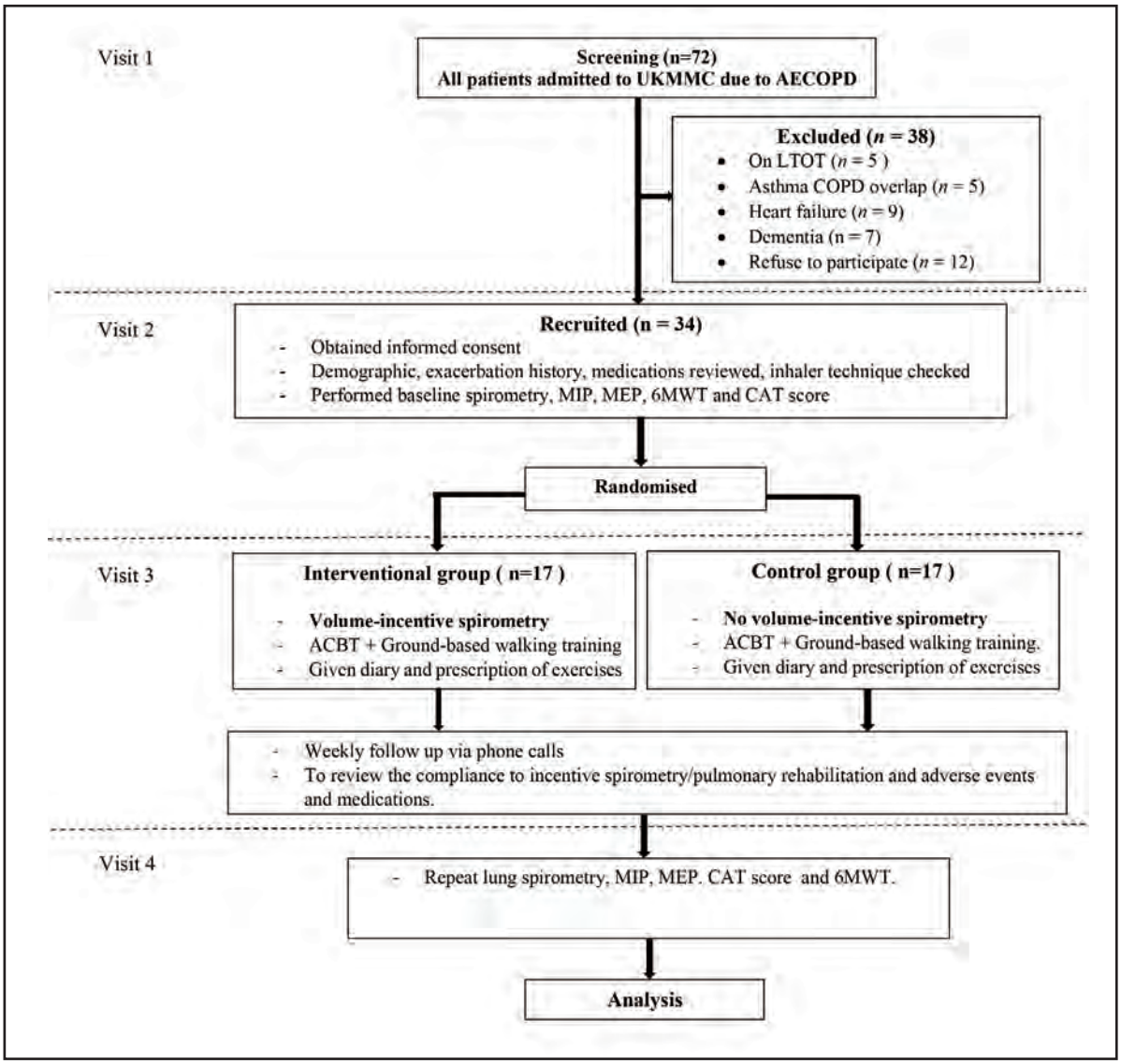

Fig. 2: Study design and flow diagram

DISCUSSION

During the first 6 months of the study, from June 2021 to December 2021, a movement control order (MCO) was in effect due to the COVID-19 pandemic. This period saw a significant reduction in patient mobility and healthcare facility visits. Following the relaxation of the MCO in January 2022, there was a noticeable decrease in hospital admissions for exacerbations of COPD.

The majority of subjects in this study were male (94%), and 14.7% of the participants were active smokers (Table I). These are consistent with known higher prevalence of COPD among males and smokers.[11,12]

COPD patients are typically not obese.[13] In our study, over half of the subjects were classified as overweight. This observation reflects the broader trend of rising obesity rates in Malaysia, where approximately one or two individuals is overweight.[14] Obesity in COPD has demonstrated mixed effects; reduced 6 minute-walk distance, worse dyspnoea, poor quality of life and an increased risk for hospitalisation for exacerbations but also lower mortality and higher lung functions.[15,16] While one study in Taiwan and another in China suggest COPD patients who are obese may have a lower exacerbation rate than leaner COPD patients.[17,18]

Exacerbations play a significant role in the clinical course of COPD. In our study, 94.11% of patients had a history of at least two exacerbations in the past year. This figure exceeds those reported in other studies of inpatient pulmonary rehabilitation, which typically showed improvement over 12 weeks.[19,20] The frequency of exacerbations is associated with a progressively higher risk of mortality; each additional moderate exacerbation further elevates the risk of death, with the risk increasing substantially with severe exacerbations.[21]

In COPD patients, lower MIP and MEP typically indicate reduced respiratory muscle strength and can contribute to

increased respiratory symptoms and reduced exercise tolerance. COPD patients hospitalised for exacerbations have been reported to have low MIP.[22] In our study, the baseline MEP and MIP values were lower compared to those reported in other studies, which documented higher baseline MEP and MIP values.[19]

In our study, a higher proportion of patients were on supplemental oxygen therapy, including NIV, whereas other studies included patients who did not require oxygen therapy.[19,20] This is likely attributable to the lower MIP and MEP values observed.

Early rehabilitation during hospital admission for chronic respiratory diseases has not been shown to reduce subsequent readmission rates or improve physical function recovery over 12 months, with higher mortality observed in the intervention group.[22] These results suggest that progressive exercise rehabilitation may not offer additional benefits beyond standard physiotherapy in the early stages of an acute illness. However, our study found that initiating inpatient pulmonary rehabilitation at 48 hours post-admission is safe, indicating that while early rehabilitation may not enhance long-term outcomes, it does not compromise patient safety when carefully managed.

In our study, we utilised a specific approach by combining VIS with the active-cycle-breathing technique (ACBT), distinguishing it from other inpatient pulmonary rehabilitation (PR) designs. VIS focuses on enhancing lung volumes and inspiratory muscle strength, while ACBT targets mucus clearance and improved ventilation. The combined approach aimed to address multiple aspects of respiratory function simultaneously.[23] In our study, the addition of VIS to ACBT and ground-based walking training resulted in a significant improvement in the 6MWT.

There was a numerical improvement in both MEP and MIP after the intervention, although the changes were not statistically significant. This may be attributed to the study population's higher history of exacerbations and lower baseline MIP and MEP values, indicating poorer muscle strength. Oliveira et al. reported significant changes in MIP after 45 days of COPD exacerbation. Our study, which had a shorter duration of 4 weeks, may have been too brief to detect significant changes. A longer duration might be necessary to demonstrate the significance of such improvements.[24]

The CAT is a questionnaire designed to evaluate the impact of COPD on a patient's health status and quality of life with higher scores indicating greater disease impact and poorer health status. Studies have shown that higher CAT score categories are associated with a significantly shorter time to first exacerbation and higher exacerbation risk.[25] In our study, at baseline, the median CAT score was high (Table I). This is an expected finding as all subjects were in exacerbation.

In the intervention group, the mean CAT score decreased from 22 to 11, while in the control group, it decreased from 21 to 10; both changes were statistically significant. These reductions signify substantial improvements in the impact of COPD on patients' health status and quality of life. The findings suggest that both treatment approaches, whether the intervention or standard care, effectively alleviated symptoms and enhanced overall well-being, demonstrating the effectiveness of these strategies in managing COPD and improving patient outcomes.

CONCLUSION

Early initiation of pulmonary rehabilitation in patients with acute exacerbations, characterised by poor muscle strength and a history of exacerbations, resulted in significant improvements in patient-reported symptoms and 6-minute walk test (6MWT) outcomes. Although there was only a numerical improvement in maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP), the intervention did not extend the length of hospital stay, highlighting its safety and efficacy in the acute care setting.

STUDY LIMITATION

The study had several limitations. The small sample size suggests that a longer follow-up period might have provided more robust data. Additionally, the lack of supervision could have led to suboptimal use of VIS techniques by the subjects. Future prospective studies are needed to compare the effectiveness of VIS in stable versus acute exacerbations of COPD.

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ETHICS DECLARATIONS

Ethics approval and consent to participate

This study was approved by the Medical Ethics Committee of Universiti Kebangsaan Malaysia Medical Centre (FF-2020-444), and it is in accordance with the Helsinki Declaration (IV adaptation). Written informed consent was obtained from all participants.

COMPETING INTERESTS

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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