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Effect Of Acapella Versus Lung Flute On Pulmonary Function, Exercise Capacity, And Quality Of Life In Chronic Obstructive Pulmonary Disease Patients: A Randomised Clinical Trial

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Abstract
Background and Purpose: *Chronic obstructive pulmonary disease (COPD) is a treatable condition often complicated by excess mucus, which impairs lung function and lowers quality of life (QoL). Positive expiratory pressure (PEP) devices, such as Acapella and Lung Flute, are non-pharmacological physiotherapy options for managing COPD symptoms. Our objective is to compare the effects of Acapella versus Lung Flute on pulmonary function, exercise capacity and QoL in patients with COPD.*
Methods: *A randomized clinical trial was conducted involving 70 male COPD patients aged 40–60 years, divided into two groups: Acapella and Lung Flute. Both groups received conventional chest physiotherapy along with their respective devices over eight weeks. Primary outcomes included forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), and FEV_1/FVC ratio. Secondary outcomes were the six-minute walk test (6MWT), VO_2 max (mL/kg/min), modified Medical Research Council (mMRC) dyspnoea scale, and the VQ11 QoL questionnaire.*
Results: *Both groups showed significant improvements in FEV_1 (Acapella: $p = 0.021$; Lung Flute: $p = 0.035$), FVC (Acapella: $p = 0.015$; Lung Flute: $p = 0.042$), 6MWT ($p < 0.001$ for both), and VQ11 scores ($p < 0.001$). The Acapella group showed significantly greater improvements in FEV_1 ($p = 0.007$), FVC ($p = 0.047$), 6MWT ($p = 0.035$), and mMRC scores ($p = 0.010$) compared to the Lung Flute group. No significant changes were found in the FEV_1/FVC ratio or VO_2 max ($p > 0.05$).*
Discussion: *Acapella is more effective than Lung Flute in enhancing pulmonary function, exercise capacity, and QoL in COPD patients.*
Keywords: *Pulmonary Rehabilitation, Positive Expiratory Pressure, Exercise Capacity, Dyspnoea, Quality of Life, Physiotherapy, Metres.*

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a prevalent, preventable, and manageable condition. It is characterized by chronic respiratory symptoms and airflow limitation resulting from airway and/or alveolar abnormalities, most commonly caused by prolonged inhalation of harmful gases or particulate matter[1]. Globally, COPD ranks among the top three causes of mortality, particularly in low- and middle-income countries [2]. In Egypt, COPD affects approximately 7.5% of the population, with a notable gender disparity showing higher prevalence among men[3].

One of the most critical challenges in COPD management is mucus accumulation in the airways. This leads to increased airway resistance, recurrent infections, and exacerbation of symptoms [4]. In COPD patients, excessive mucus build-up significantly impairs lung function, increases the frequency and severity of exacerbations, raises hospital admission rates, and negatively affects survival outcomes[5]. The overarching aim of COPD management is to reduce the risk of exacerbations and relieve symptoms[6].

Consequently, comprehensive treatment approaches are necessary for this patient population, including interventions aimed at reducing dyspnoea, improving exercise tolerance, and enhancing quality of life (QoL)[7]. Non-pharmacological strategies for clearing airway secretions include physiotherapeutic techniques such as positive expiratory pressure (PEP) devices [8].

Acapella is a hand-held, portable device that combines positive expiratory pressure, forced exhalation, and oscillatory vibrations to facilitate airway clearance. PEP enhances airflow behind mucus plugs and alters the rheological properties of sputum, allowing secretions to be mobilised without causing over-inflation of the lungs[9].

The Lung Flute, an oscillating PEP device, is a reusable, non-invasive plastic tool known for its simplicity and drug-free mechanism[10]. It comprises a mouthpiece and a reed enclosed within a rectangular plastic tube (36–38 cm in length) and generates sound waves at a frequency of 18–22 Hz [11]. When the user exhales forcefully, it produces sound levels of 110–115 dB at 2.5 cmH_2O pressure [10]. These acoustic waves propagate through the tracheobronchial tree, loosening mucus and stimulating mucociliary clearance, particularly in the lower airways [11].

Although both devices have demonstrated clinical benefits in previous studies (Dos Santos et al. 2013; Elhawary et al. 2020), there is a lack of direct comparative data on their effectiveness in patients with COPD.

This study aimed to evaluate the extent to which the Acapella and Lung Flute devices can improve pulmonary function, exercise tolerance, and QoL in COPD patients. By comparing these two airway-clearance methods, the study seeks to provide evidence-based recommendations for optimizing COPD management.

METHODS

Study Design and Setting

This study was a controlled, randomized trial involving 70 male patients diagnosed with chronic obstructive pulmonary disease (COPD). Prior to the intervention, all participants provided written informed consent after being fully briefed on the study's objectives, procedures, and their rights as participants. Patients were informed about the study program before commencing any interventions. Throughout the trial, participants continued their regular prescribed medications, and were free to withdraw at any time without consequence.

The study received ethical approval from the Ethics Council of the Faculty of Physiotherapy, Cairo University (Approval No. Hidden for review) and was registered on ClinicalTrials.gov (Hidden for review). The study was conducted in accordance with the principles outlined in the Declaration of Helsinki.

Following initial screening and a battery of baseline assessments, participants underwent clinical evaluation and individual interviews at the Pulmonology Department, Faculty of Medicine, Cairo University. Evaluated parameters included pulmonary function, exercise capacity, and quality of life (QoL). All assessments were conducted using the same protocols for both intervention groups.

Participants

This controlled randomized study included 70 male COPD patients aged 40 to 60 years, recruited between 12 March 2023 and 1 October 2024. Participant selection followed specific inclusion criteria: body mass index (BMI) between 25 and 34 kg/m^2; medically stable status; a minimum smoking history of 10 pack-years (current or former smokers); and spirometry-confirmed airflow obstruction defined by a post-bronchodilator forced expiratory volume in one second (FEV_1)/forced vital capacity (FVC) ratio < 70% and FEV_1< 80% of predicted, consistent with moderate to severe COPD as classified by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines.

Exclusion criteria included: recent COPD exacerbation (within four weeks of enrolment); clinically significant asthma or bronchiectasis; long-term use of mucolytic agents; contraindications to spirometry (e.g., recent thoracic or abdominal surgery, unstable cardiovascular conditions, elevated intraocular, intracranial, middle ear, or sinus pressure, or communicable infections); and any condition limiting safe participation in the six-minute walk test (6MWT), such as resting tachycardia, recent myocardial infarction, or uncontrolled hypertension.

Sample size calculation

The primary outcome measure was FEV_1 at the eighth week. This study was designed with 95% power to detect a 10% difference in FEV_1 values between the two treatment groups by week eight. Assuming a standard deviation of 13%, based on prior research12, and using a two-sided significance level of 5%, a

minimum of 35 patients per group was required (Power and Sample Size Calculation software, version 3.0.43, Vanderbilt University Medical Centre, Nashville, TN, USA).

Randomization

Eligible participants were block-randomized into two groups (Acapella and Lung Flute) using SAS software (version 9.4; SAS Institute, Inc.), with random block sizes of 2 and 4 and an allocation ratio of 1:1. Participants were blinded to their assigned interventions. Outcome assessors were also blinded to group allocation to ensure unbiased assessment. The trial was conducted in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines. The study flow is illustrated in the CONSORT diagram **(Figure S1).**

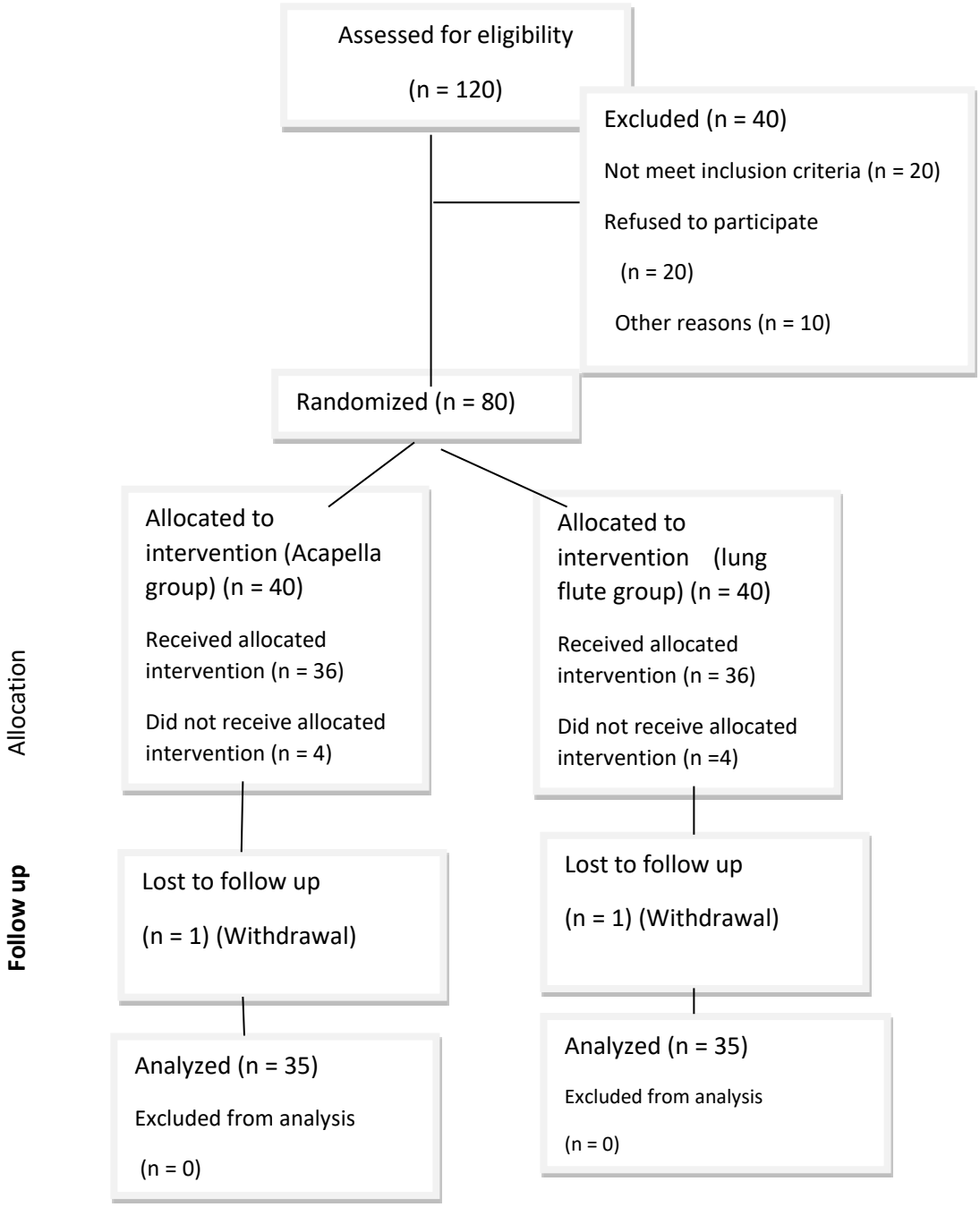

FIGURE S1. Flow chart of the study.

Outcome measures

Primary Outcome

1. Pulmonary function

Spirometry was employed to assess lung function. A qualified technician conducted the spirometry evaluation using the SpiroUSB instrument (CareFusion Germany 23X), in accordance with the American Thoracic Society (ATS) guidelines. The clinician ensured proper participant positioning, correct application of the nose clip, and a complete lip seal around the mouthpiece. Each participant completed a minimum of three and up to eight expiratory blows, each lasting approximately six seconds, as per standard testing criteria. Acceptable measurements were defined as having less than a 5% difference between the two highest values and a minimum volume of 150 ml[13] (**Figure S4**).

Figure S4. Pulmonary function assessment

2. Six-Minute Walk Test (6MWT)

The test was conducted indoors along a 30-metre, hard, flat corridor with clearly marked turning points. Participants were instructed to walk at their own pace and pause if necessary. The greatest distance covered during the 6MWT, recorded from two attempts, was measured in metres and statistically analyzed [14]. This distance was then used to estimate VO_2max (ml/kg/min) using the following formula: VO_2 max = 12.701 + (0.06 × 6-minute walk distance in meters) – (0.732 × body mass index in kg/m²) [15].

3. Quality of Life (QoL)

Quality of life was assessed using the VQ11 questionnaire, a validated and reliable tool for individuals with chronic respiratory conditions. The questionnaire comprises 11 items divided into three domains: functional (three items), psychological (four items), and relational (four items). Total scores range from 11 to 55, with higher scores indicating poorer quality of life[16].

The secondary outcomes

1. Modified Medical Research Council (mMRC) Scale

The mMRC scale is a simple and reliable tool for assessing the impact of breathlessness on daily activities. It uses a 0–4 grading system and is widely accepted for classifying COPD severity. Patients were introduced to the mMRC scale, instructed on its use, and asked to rate their dyspnoea accordingly. The test–retest reliability was high, with a value of 0.82, indicating strong consistency[17].

Intervention

The intervention period lasted eight weeks, during which patients received therapy on alternate days. Participants were randomly allocated into two equal groups. Both groups received standard chest physiotherapy, which included diaphragmatic breathing exercises, postural drainage, vibration, and huffing techniques. This conventional physiotherapy was aimed at enhancing airway clearance and improving respiratory function in all participants 18 in addition to Acapella device for Group A and Flute device for group B.

Group A: Acapella group

The Acapella® OPEP device (Green-DH model; Smiths Medical International, Ltd., Minneapolis, MN, USA) was utilized. The device employs a counterweighted plug and a magnet to produce oscillatory airflow during exhalation. Participants, while seated, were instructed to exhale through the device, maintaining a continuous airflow for 10–15 breaths per cycle. Each cycle was followed by a huffing maneuver to aid in airway clearance.3 days (alternatively a week) for eight consecutive weeks.
Participants were instructed to cough to facilitate mucus expectoration as necessary. This procedure was repeated three to five times per session, depending on the patient's tolerance and the volume of mucus produced[19] **(figure S2)**

Figure S2. Acapella application.
Group B: Lung flute group
The Lung Flute (Medical Acoustics, Buffalo, New York, USA) was utilized. Participants were instructed to exhale into the device 15–20 times per cycle. Following each cycle, they performed huffing or coughing maneuvers to expel the loosened secretions. As with the Acapella group, this procedure was repeated three to five times per session, depending on patient comfort and the amount of mucus produced [20] three days (alternatively a week) for eight consecutive weeks.
Each intervention session lasted approximately 30 minutes, ensuring that both groups received equal treatment duration. Throughout the sessions, all participants were continuously monitored, and the approach was adjusted as needed based on individual responses. Patients were also instructed to continue their prescribed medications, including bronchodilators and corticosteroids, in accordance with their physicians' guidance [21].
Therapists delivering the treatment were trained in both Acapella and Lung Flute techniques, ensuring consistent application across sessions. Patients were asked to maintain logs documenting their attendance and participation to support adherence monitoring. To assess immediate post-session outcomes, participants were encouraged to report any discomfort, changes in symptoms, or perceived benefits following each treatment session **(Figure S3).**

Figure S3. Lung flute application

Data Collection

All study data were recorded in a systematic manner by using standardized documentation forms and stored in secure, digital databases accessible are exclusive only to authorized research personnel and it was password protected. Author preserved patient anonymity through de-identified data handling procedures

Statistical Analysis

Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS), version 23.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative variables with parametric distributions were expressed as mean ± standard deviation and ranges; non-parametric data were presented as median and interquartile range. Qualitative variables were summarized using counts and percentages.

Normality of data distribution was assessed using both the Kolmogorov–Smirnov and Shapiro–Wilk tests. Between-group comparisons for continuous variables were conducted using the independent-samples t-test, while within-group analyses used paired-samples t-tests. Categorical variables were compared using the Chi-square test, with Fisher's exact test applied where expected frequencies were below five. Statistical significance was set at $p < 0.05$.

RESULTS/ FINDINGS

As shown in **table S1**, there were no statistically significant differences between the Acapella and Lung Flute groups at baseline in terms of age (years), weight, height, body mass index (BMI), six-minute walk test (6MWT), VO_2 max, forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), FEV_1/FVC ratio, VQ11 questionnaire score, or modified Medical Research Council (mMRC) dyspnoea score ($p > 0.05$) ,.

TABLE S1. Comparison between the Acapella group and the Lung Flute group at baseline.

Baseline characteristics	Acapella Group (n=35)	Lung Flute Group (n=35)	Test value	p-value
Age (years)	48.43±6.08	49.69±5.66	-0.895	0.374
Weight (kg)	85.18±8.56	83.69±9.23	0.698	0.487
Height (cm)	174.91±6.80	174.66±7.67	0.148	0.882
BMI (kg/m^2)	27.79±1.57	27.36±1.62	1.108	0.272
FEV1 (liters)	1.59±0.22	1.45±0.13	1.948	0.072
FVC (liters)	2.99±0.20	2.94±0.23	1.029	0.307
FEV1/FVC ratio	52.41±7.14	50.23±7.22	1.574	0.112
6MWT (meters)	262.64±11.11	264.86±13.48	-0.753	0.454
Vo2Max (ml/kg/min)	13.90±0.48	13.91±0.52	-0.095	0.924

Vq11 questionnaire	30.26±3.66	30.17±3.37	0.102	0.919
mMRC dyspnea score	2.80±0.63	2.69±0.53	0.820	0.415

BMI, Body mass index; 6MWT, Six-minute walking test, FEV1,Forced expiratory volume in one second, MD: Mean difference..

Statistically significant improvements in FEV_1 were observed in both the Acapella group ($p = 0.021$) and the Lung Flute group ($p = 0.035$) following the intervention, as shown in Table S2. The Acapella group demonstrated a greater improvement (6.3%) compared to the Lung Flute group (2.8%) by the end of the study, with this difference reaching statistical significance ($p = 0.007$).
Similarly, FVC measurements showed significant improvements within both groups (Acapella: $p = 0.015$; Lung Flute: $p = 0.042$). Between-group comparison at the conclusion of the study revealed that the Acapella group had a significantly larger increase in FVC than the Lung Flute group ($p = 0.047$).
However, no statistically significant changes were observed in the FEV_1/FVC ratio within or between groups before or after treatment ($p > 0.05$). The post-intervention difference between the two groups also remained non-significant ($p = 0.148$).
Significant differences in six-minute walk test (6MWT) results between the Acapella and Lung Flute groups were observed both before and after the intervention ($p < 0.001$). At the study's end, the Acapella group achieved a notably greater improvement (14.2%) than the Lung Flute group (3.4%), with this difference being statistically significant ($p = 0.035$), as determined by the independent samples t-test. Regarding VO_2 max (ml/kg/min), no statistically significant changes were observed either within or between groups following the intervention ($p = 0.613$) **(Table 2).**
Significant improvements in quality of life, as assessed by the VQ11 questionnaire, were observed in both groups ($p < 0.001$). At the end of the study, the Acapella group showed a greater improvement (14.2%) compared to the Lung Flute group (6.7%), with this difference reaching statistical significance ($p = 0.041$) **(Table S2).**
Finally, both treatment groups showed statistically significant decreases in mMRC dyspnoea scores post-intervention ($p < 0.001$). The Acapella group achieved a more marked reduction (29.6%) compared to the Lung Flute group (10.8%), with the between-group difference also being statistically significant ($p = 0.010$) **(Table S2).**

TABLE S2. Comparison between Acapella group and Lung Flute group according to all parameters.

	Acapella group (n=35)	**Lung Flute group (n=35)**	**Independent sample t-test**	**p-value**
FEV1 (liters)				
Pre intervention	1.59±0.22	1.45±0.13	1.948	0.072
Post intervention	1.69±0.26	1.49±0.13	3.802	0.007*
MD (95% C.I.)	0.10(0.6-0.15)	0.04(0.02-0.06)		
% of change	6.3%	2.8%		
Paired sample t-test	3.433	3.317		
p-value	0.021*	0.035*		
FVC (liters)				
Pre intervention	2.99±0.20	2.94±0.23	1.029	0.307
Post intervention	3.06±0.22	2.95±0.24	2.026	0.047*
MD (95% C.I.)	0.07(0.03-0.09)	0.01(0.007-0.013)		
% of change	2.3%	0.3%		
Paired sample t-test	3.589	2.094		
p-value	0.015*	0.042*		
FEV1/FVC ratio				
Pre intervention	52.41±7.14	50.23±7.22	1.574	0.112
Post intervention	54.71±7.73	52.36±7.23	1.313	0.148
MD (95% C.I.)	2.29(1.7-2.9)	2.15(1.7-2.6)		
% of change	4.4%	4.3%		
Paired sample t-test	1.058	1.174		

p-value	0.417	0.330		
6MWT (meters)				
Pre intervention	262.64±11.11	264.86±13.48	-0.753	0.454
Post intervention	299.91±20.82	273.84±15.25	3.075	0.035*
MD (95% C.I.)	37.27(28.9-45.6)	8.98(6.9-11.0)		
% of change	14.2%	3.4%		
Paired sample t-test	4.807	3.405		
p-value	<0.001**	<0.001**		
Vo2Max (ml/kg/min)				
Pre intervention	13.90±0.48	13.91±0.52	-0.095	0.924
Post intervention	14.97±0.76	14.76±0.58	1.044	0.613
MD (95% C.I.)	1.08(0.9-1.3)	0.85(0.6-1.1)		
% of change	7.8%	6.1%		
Paired sample t-test	1.344	1.041		
p-value	0.316	0.610		
Vq11 questionnaire				
Pre intervention	30.26±3.66	30.17±3.37	0.102	0.919
Post intervention	25.97±4.94	28.14±4.59	-2.055	0.041*
MD (95% C.I.)	-4.29(-5.4to-3.2)	-2.03(-2.6to-1.5)		
% of change	-14.2%	-6.7%		
Paired sample t-test	5.422	4.724		
p-value	<0.001**	<0.001**		
mMRC dyspnea score				
Pre intervention	2.80±0.63	2.69±0.53	0.820	0.415
Post intervention	1.97±0.71	2.40±0.65	-2.640	0.010*
MD (95% C.I.)	-0.83(-1.1to-0.6)	-0.29(-0.4to-0.2)		
% of change	-29.6%	-10.8%		
Paired sample t-test	6.996	5.808		
p-value	<0.001**	<0.001**		

6MWT, Six-minute walking test; FEV1, Forced expiratory volume in one second;

DISCUSSION

A key objective in COPD management is to alleviate and prevent symptoms such as coughing, dyspnoea, symptom exacerbation, and airway mucus accumulation. Clinical evidence has shown significant improvement through the use of oscillatory positive expiratory pressure (OPEP) devices. By facilitating lung emptying, OPEP may help conserve energy and oxygen, reduce pulmonary infections, and lower hospital readmission rates. Airway clearance strategies such as chest vibration, percussion, breathing exercises, and devices like Acapella and the Lung Flute have proven beneficial in removing excessive sputum[8].

In this study, both the Lung Flute and Acapella groups demonstrated significant post-intervention improvements in FEV_1 and FVC, with the Acapella group exhibiting the most substantial gains ($p < 0.05$). No significant changes in FEV_1/FVC ratio were observed within or between groups across all time points ($p > 0.05$). These findings align with those of Jaiswal et al. (2019)[22] who reported significant improvements in FEV_1/FVC ratios following Acapella training ($p = 0.002$, $p = 0.004$), although some COPD patients in that study did not show notable FEV_1/FVC changes ($p = 0.38$). Similarly, Shaikh S, Vardhan (2019)[23] found no significant changes in FEV_1/FVC ratio despite some improvements in both FEV_1 and FVC among Lung Flute users ($p < 0.0001$).

Statistically significant differences were also found between groups in the 6MWT before and after the intervention ($p < 0.001$); with the Acapella group showing greater post-treatment improvement (14.2%) than the Lung Flute group (3.4%) ($p = 0.035$). Chen et al. (2023)[24] observed comparable improvements in lung function and exercise capacity using Acapella and active cycle of breathing techniques (ACBT) in

perioperative lung cancer patients. Dsilva et al. (2020)[25] similarly reported significant improvements in 6MWT distances after treatment with the Lung Flute in COPD patients (85.00 ± 73.82; $p < 0.05$).

No statistically significant differences were observed in VO_2max (ml/kg/min) between pre- and post-intervention values or between groups ($p > 0.05$; $p = 0.613$). To date, no studies have evaluated the effect of Acapella or Lung Flute on VO_2max.

VQ11 questionnaire scores improved significantly in both treatment groups post-intervention ($p < 0.001$), with the Acapella group showing a higher level of improvement (14.2%) compared to the Lung Flute group (6.7%) ($p = 0.041$). These results correspond with those of Alghamdi et al. (2023)[26] who found that regular use of OPEP devices improved symptoms and quality of life in COPD patients experiencing daily or near-daily sputum production.

Post-intervention mMRC dyspnoea scores were significantly lower in both groups, with the Acapella group showing a greater reduction than the Lung Flute group ($p < 0.05$). The overall reduction in scores was highly significant ($p < 0.001$). These findings support those of Rai et al. (2019)[27] who confirmed the effectiveness of Acapella in reducing dyspnoea when used at home in patients with severe COPD. Mekala et al. (2023)[28] also reported significant reductions in dyspnoea following Lung Flute use in COPD patients ($p < 0.001$).

Several studies have demonstrated that improvements in FEV_1 result from reduced airway resistance and improved collateral ventilation due to OPEP-induced airway expansion [8]. Increased FVC is attributed to alveolar recruitment and secretion clearance, which in turn reduce airway obstruction[24]. OPEP therapy enhances tidal volume, promotes alveolar emptying, and reduces functional residual capacity during expiration [26]. The back-pressure generated by OPEP splints open distal airways, temporarily increasing lung capacity and improving ventilation behind obstructed segments [29-35]. These physiological improvements enable COPD patients to perform daily activities with greater ease, thereby enhancing their overall functional capacity and quality of life[36-40].

Strengths of the Study

This study presented a prospective, randomised controlled design with both within group and between-group comparisons, thereby improving its methodological rigour and internal validity [41-43]. The interventions were delivered using standardised protocols, and outcome assessors were blinded to group allocation, minimising bias in data collection and interpretation.

A combination of objective physiological measures (FEV_1, FVC, VO_2Max, and 6MWT) and validated patient-reported outcomes (VQ11 and mMRC scales) were used to comprehensively assess treatment effects. This dual approach ensured that the study addressed both functional capacity and the patient experience, providing a holistic evaluation of clinical effectiveness.

Moreover, the use of a defined intervention duration, strict inclusion/exclusion criteria, and consistent monitoring across sessions supports the reproducibility and reliability of the findings. The inclusion of two OPEP devices adds practical value by directly informing physiotherapy practice and decision-making in airway clearance strategies for COPD

Limitations

The intervention in this study was limited to duration of eight weeks. While significant short-term improvements were observed, the long-term effects of Acapella® and Lung Flute® on pulmonary function, exercise tolerance, and quality of life remain uncertain. Furthermore, the study included only male patients aged 40 to 60 years with moderate to severe COPD, which limits the generalisability of the findings to older individuals and females. Recruitment was confined to Kasr Al Ainy Hospital, Cairo University, and therefore the sample may not be representative of the wider Egyptian population or other global regions, where environmental and socioeconomic factors influence COPD presentation.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

We recommend integrating Acapella® and Lung Flute® devices into pulmonary rehabilitation protocols for COPD patients to enhance ventilatory function, exercise capacity, and quality of life. The potential for complementary effects warrants further exploration.

And also conduct long-term studies on Acapella® to examine its sustained effects on pulmonary function, symptom control, exercise tolerance, and annual exacerbation frequency, as well as its influence on sputum production with continued use.
Additionally to investigate the long-term impact of Lung Flute® use on exacerbation rates and quality of life measures to determine its utility in chronic disease management.
In addition, assess the efficacy of both devices across different age groups to determine whether age moderates the therapeutic response in COPD patients.
Finally, to evaluate device effectiveness across sexes to explore potential differences in treatment outcomes between male and female COPD populations.

CONCLUSION

In incorporating non-pharmacological devices such as Acapella® and Lung Flute® into conventional COPD management, this study observed significant improvements in ventilatory function, exercise capacity, quality of life, and dyspnoea. Acapella® consistently outperformed the Lung Flute® across all outcome measures, likely due to its mechanism of action, ease of use, and clinical efficacy. These findings support the recommendation of Acapella® as a preferred adjunct in pulmonary rehabilitation strategies for individuals with moderate to severe COPD

Implications of Physiotherapy Practice

This study supports the inclusion of Acapella and Lung Flute devices as effective components of comprehensive pulmonary rehabilitation. Their demonstrated efficacy in improving lung function, exercise capacity, and quality of life emphasises the value of non-pharmacological therapies in COPD management. These findings also provide a foundation for future research exploring the long-term benefits, cost-effectiveness, and broader integration of OPEP techniques into clinical practice.

Patient Consent

The study procedures were elucidated to the patients, and they provided their consent by signing forms before the commencement of the study procedures.

Data Availability

Available upon request.

Ethical Considerations and Registration

This study was approved by the Ethics Committee of the Faculty of Physical Therapy, Cairo University (Approval No: P.T.REC/012/002208). All procedures followed the Declaration of Helsinki. The trial was registered at ClinicalTrials.gov (Identifier: NCT06801106).

Authors' Contributions

All authors jointly conceived and designed the study. HAA conducted the material preparation, data collection, and analysis. AAS drafted the initial manuscript, and all authors contributed to its revision. All authors reviewed and approved the final manuscript.

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