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Effectiveness of oscillatory instrumental bronchial clearance techniques in the treatment of Chronic Obstructive Pulmonary Disease, a systematic review

Efectividad de las técnicas instrumentales oscilatorias de desobstrucción bronquial en el tratamiento de la Enfermedad Pulmonar Obstructiva Crónica, una revisión sistemática

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Abstract. Introduction: Bronchial clearance techniques using oscillatory instrumental devices used in the approach to the COPD patient can improve the cough pattern and favor expiratory flow, thus facilitating the expulsion of secretions, avoiding atelectasis, favoring ventilatory mechanics, oxygenation and maintenance of a patent airway. Methods: A systematic review was carried out following the inclusion criteria based on a search of electronic databases such as: PubMed, Science Direct, Scopus, Springer, Google Scholar, between the period 01/05/2023 to 01/02/2024 in English, Spanish and Portuguese, including studies such as Randomized Clinical Trials and cohort studies. Results: A total of 14 articles were included, 100% in English. The number of participants was 3105, aged between 35 and 85 years, 50.2% of the participants were women. High Frequency Chest Wall Oscillation (HCFWO®) was the most commonly used device 35.7% n=5, followed by Flutter® 28.6% n=4. Intervention time ranged from 1 to 12 weeks, 3 to 7 times per week, 1 to 4 sessions per day, lasting 10 to 30 minutes, between 10 to 20 Hz. Conclusions: The use of HFCWO can have a positive impact on pulmonary rehabilitation, specifically on pulmonary function and oxygenation variables, when implemented as a complementary therapy to early mobilization, therapeutic exercise, and bronchial clearance breathing techniques.
Keywords: COPD, mucociliary clearance, chest wall oscillations, respiratory therapy, breathing exercises.

Resumen. Introducción. Las técnicas de desobstrucción bronquial en donde se emplean dispositivos instrumentales oscilatorios utilizadas en el abordaje del paciente con EPOC pueden mejorar el patrón de tos y favorecer el flujo espiratorio, facilitando así la expulsión de las secreciones, evitar atelectasias, favorecer la mecánica ventilatoria, la oxigenación y el mantenimiento de la vía aérea permeable. Métodos: Se realizó una revisión sistemática siguiendo los criterios de inclusión a partir de búsqueda de bases de datos electrónicas como: PubMed, Science Direct, Scopus, Springer, Google Académico, entre el periodo 01/05/2023 al 01/02/2024 en idioma inglés, español y portugués incluyendo estudios tipo Ensayos Clínicos Aleatorizados y estudios de cohortes. Resultados: En total 14 artículos fueron incluidos, 100% en idioma inglés. El número de participantes fue de 3105, con edades entre 35 y 85 años, 50,2% de los participantes fueron mujeres. Oscilación Oral de Alta Frecuencia (HFCWO®) fue el dispositivo más usado 35,7% n=5, seguido de Flutter® 28,6% n=4. El tiempo de intervención osciló entre 1 a 12 semanas, de 3 a 7 veces por semana, entre 1 a 4 sesiones diarias, con duración entre 10 a 30 minutos, entre 10 a 20 Hz. Conclusiones: El uso de HFCWO puede tener un impacto positivo en la rehabilitación pulmonar, específicamente en las variables de función pulmonar y oxigenación, cuando se implementa como terapia complementaria a la movilización temprana, el ejercicio terapéutico y a las técnicas respiratorias de desobstrucción bronquial.
Palabras claves: EPOC, limpieza mucociliar, oscilaciones de la pared del tórax, terapia respiratoria, ejercicios respiratorios.

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Introduction

Chronic Obstructive Pulmonary Disease (COPD), is defined as "a heterogeneous pulmonary condition characterized by chronic respiratory symptoms such as dyspnea, cough and sputum production, associated with abnormalities of the airways: bronchitis, bronchiolitis and of the alveoli: emphysema, which can cause persistent, sometimes progressive airflow obstruction" (Celli et al.,2022). The most frequent symptomatology in COPD is dyspnea, chronic cough, sputum production, wheezing, chest tightness and fatigue (Sarkar et al.,2019).

Instrumental techniques with oscillatory devices used for bronchial clearance in COPD patients aim to stimulate cough, increase expiratory flow to mobilize and facilitate the elimination of secretions, prevent atelectasis, favor ventilatory mechanics, improve oxygenation and maintain a patent airway (Coppolo et al.,2022). Oscillatory devices include small, portable and low-cost equipment such as the Flutter, Acapella, Quake, RC-Cornet, Thera PEP (Belli et al.,2021), (Daynes et al.,2019), and mechanical equipment with greater technological development such as the inflatable vest (HFCWO), the Uniko – TPEP (Teresa et al.,2013).

Oscillatory devices are portable devices that generate a positive pressure or a continuous or intermittent frequency in the active exhalation phase; the positive pressure stimulates the flow inside the secretions, while the oscillations are the product of overcoming a resistance; these vibrations are transmitted from the oral cavity to the bronchial ducts creating shear forces in the viscoelastic properties, that is, the thickness of the secretions, thus facilitating their displacement and improving their elimination (Gupta et al.,2022) (Maggie et al.,2017). Devices frequently employed for this purpose are:

Flutter®: Contains internal steel balls that vibrate during exhalation, which alter the outward flow (Daynes et al.,2019). Acapella®: Produces intermittent vibrations by overcoming a resistance to the exhaled air flow (Palíz et al., 2021).

Cornet®: The horn has a rubber inner tube. The degree of rotation of this inner tube shows the effect of the resistance. When a person breathes through the horn, the inner tube twists, which causes the inner tube to twist and turn inward rhythmically during exhalation (Amit et al.,2012). Quake®: This device uses a manually rotating cylinder that is placed inside another cylinder causing a flow of air to occur when the valves inside the two cylinders are aligned (Amit et al.,2012). Extrathoracic oscillations (HFCWO) - Vest® or Hayek Oscillator®: External chest compressions are performed using a breathing mask connected to a machine that vibrates at different frequencies and intensities set by the user to find comfort and individual compliance (Lerman et al.,1996). Vibralung®: An acoustic striker, it generates sound waves that go directly to the tracheobronchial tract within a frequency range of 5 to 1200 Hz, covering a range of resonant frequencies of the human tracheobronchial tract, this frequency causes vibration within the airways and mucus (Wheatley et al.,2018).

Metaneb®: A pneumatic compressor system that generates continuous high frequency oscillations and continuous positive expiratory pressure (Ferguson et al.,2017). Aerobika®: It is a portable device that manages an oscillating positive expiratory pressure (Khoudigian-Sinani et al.,2017). It works when the person exhales through the device, the intermittent resistance creates a single, dynamic and oscillatory pressure, expanding the airway and mobilizing mucus into the upper airways (Tayade V et al.,2023).

Respiratory techniques for bronchial clearance: Active Cycle Breathing Techniques (ACBT) and Autogenous Drainage (AD), Conventional Chest Physiotherapy (CPT) and exercise are manual physiotherapeutic techniques, which are implemented for bronchial clearance: ACBT: Relates three breathing techniques consisting of breath control, thoracic expansion exercises with emphasis on inspiration and forced expiration technique (Lewis et al.,2012). AD: Its main objective is to mobilize distal or middle secretions towards proximal, taking into account three phases: detachment, accumulation and evacuation in three pulmonary volumes: low, medium and high (Burnham et al.,2021). CPT: Conventional therapy techniques include postural drainage techniques, percussion and vibration (Freitas et al.,2018). Exercise: Exercise is one of the best therapies to clear airways or to complement with other techniques (Yun et al.,2021).

The literature reports a systematic review and meta-analysis on the evidence of the usefulness of respiratory muscle training in COPD (Beaumont et al.,2018). However, no systematic reviews have been found on the effectiveness of instrumental oscillatory bronchial clearance techniques in the management of COPD. The present research arises from the need to analyze the effectiveness of instrumental oscillatory techniques of bronchial clearance in the treatment of COPD, in order to expand and provide scientific evidence to support the knowledge of professionals in charge of the treatment and rehabilitation of these patients, and thus can base the prescription of oscillatory devices ensuring reliability, safety and better results with the intervention. A better understanding based on the scientific literature of the effects of the implementation of oscillatory instrumental techniques in the approach to the COPD patient could favor their use.

Consequently, the following research question was posed: What is the effectiveness of oscillatory instrumental bronchial clearance techniques in the treatment of COPD? The general objective of this study was to identify the effectiveness of oscillatory instrumental bronchial clearance techniques in the treatment of COPD, a systematic review 2013 - 2023. The specific objectives were to describe the characteristics of the literature found and to analyze the effect of oscillatory instrumental bronchial clearance techniques for the treatment of COPD on pulmonary mechanics, quality of life and functionality.

Materials and methods

Sources of information search

Research was analyzed in relation to the study variables and included Controlled Clinical Trials (CCT) and Cohort Studies (CS), from 2013 to 2023, resorting to reviews describing the needs of the search from the electronic databases: PubMed, Science Direct, Scopus, Springer, Google Scholar, between the period 01/05/2023 to 01/02/2024 in English, Spanish and Portuguese.

The following Mesh terms were used for the search and the different combinations were used with the boolean operators: (Pulmonary Disease, Chronic Obstructive OR COPD OR Chronic Obstructive Lung Disease OR Chronic Obstructive Pulmonary Diseases OR Chronic Obstructive Airway Disease OR Airflow Obstruction, Chronic) AND (Mucociliary Clearance OR Clearance, Mucociliary OR Mucociliary Transport OR Transport, Mucociliary) AND (Chest Wall Oscillations OR External Chest Wall Oscillation) AND (Respiratory Therapy). Connectors were used in the different possible combinations of the terms used to reach the largest possible number of articles.

Registration in Prospero

CRD42023440232

Search strategy

Data extraction (selection and coding)

The extraction of information from the included articles was performed by three researchers who collected the data (IN), (AM), (SQ) and another one who checked them (NC).

After this stage, the agreement and disagreement of the content of the selected articles was confronted among the researchers. The objective of this stage was to identify the studies that met the inclusion and exclusion criteria. Subsequently, the articles were read in their entirety and a critical analysis of the characteristics of the research was carried out. The data extracted from the study was information related to the effectiveness of oscillatory instrumental bronchial clearance techniques in the treatment of COPD. We chose to carry out a systematic review according to the checklist proposed by the PRISMA ScR.

Evaluation of the risk of bias (quality)

After the extraction of information, the agreement and disagreement of the content of the selected articles among the researchers will be confronted. Discussion and call for the fifth author (AS) was established in cases of disagreement among the authors. This avoided the risk of selection bias in the articles/studies included. The presence of bias was identified using a funnel plot and statistical tests. The PEDro scale was used for randomized clinical trials, this scale consists of 11 items where 1 is scored if it complies and 0 if it does not comply and according to the sum of the score, it is determined whether the methodological quality of the article is low, intermediate or high, taking into account aspects such as adequate control group, blinding and randomization (Matos et al.,2020). The minor's scale was used for observational case-control studies, cohort studies, prospective longitudinal studies. This scale consists of 12 items, where 0 is evaluated if not reported, 1 if reported but inadequate and 2 if reported and adequate, it takes into account aspects such as defined objectives, prospective collection, blinding, sample size calculation, adequate statistical analysis, once the points are added up it is established that the ideal score would be 16 for non-comparative studies and 24 for comparative studies (Slim et al., 2003).

Data synthesis strategy

A qualitative summary of the included study designs, population characteristics, number of participants in each study, databases, language, and the effect of oscillatory instrumental bronchial clearance techniques for the treatment of COPD on lung function and airway patency was performed.

Types of interventions

Studies were included in which oral and chest wall oscillatory devices were used in comparison with bronchial clearance breathing techniques such as autogenic drainage, active breathing cycle, conventional chest physiotherapy and exercise.

Main results

We included those studies whose primary variables collected were Forced Expiratory Volume in the First Second (FEV1), Forced Vital Capacity (FVC), Expiratory Reserve Volume (ERV), Residual Volume (RV). Sputum volume and weight, oxygen saturation (Sat02), arterial oxygen pressure (Pa02). Additionally, those studies in which quality of life, functionality and exercise tolerance were included as variables were also included.

Eligibility Criteria

Inclusion criteria

Studies performed in patients with COPD, in which oscillatory instrumental bronchial clearance techniques are performed, with any of the following devices: Flutter® - Acapella® - Cornet® - Quake® - Vest® - Hayek Oscillator® - Vibralung® - Metaneb® - Aerobika®. Control group: Bronchial clearance breathing techniques such as autogenous drainage, active breathing cycle, conventional chest physiotherapy and exercise.

Studies in which the following were measured Pulmonary mechanics: Respiratory function: Forced Expiratory Volume in the first second (FEV1), Forced Vital Capacity (FVC), Expiratory Reserve Volume (ERV), Residual Volume (RV). Sputum: volume and weight. Oxygen saturation (SaO2) and arterial oxygen pressure (PaO2) in response to treatment. Exacerbation frequency level in response to treatment. Additional outcomes: Quality of life and functionality: Exercise tolerance (measured by recognized standard exercise tests, walking tests, step tests or cycle ergometry). Quality of life and function indices and questionnaires.

Exclusion Criteria

Studies in which respiratory bronchial clearance techniques were performed that did not include oscillatory techniques. Systematic review studies, case series and case reports were not included.

Data Analysis

Data extraction and collection process: In the preliminary search with the combination of terms, a search equation was developed for the mentioned databases, studies were located from which by filtering by year, they were reduced to studies that were downloaded for analysis using Microsoft Excel, in the first selection of studies was made based on title and abstract, with the objective of specifying whether the study or article found addressed the topic in question and solved the question posed in the research, in the same way duplicates were eliminated.

The selection process according to the collection of data or bibliographic references, a Microsoft Excel matrix was created where it was filtered by phases, phase 1 with the following items: ID, title, abstract, type of study, URL. This with the objective of verifying if they met the inclusion criteria taking into account the title and abstract; finally phase 2 which had the following items: ID, title, abstract, journal data, URL, type of study, study objective and abstract, included

yes/no, reason for exclusion.

he data management according to the collection of the bibliographic references a Microsoft Excel matrix was created where it was filtered by phases, in phase 1 the following tables were developed: Table 1. Characteristics of the bibliography: Authors, title, database, journal, type of study, country, continent, language, year, objective. Table 2. Characteristics of participants: Sex, age, BMI, comorbidities, inclusion and exclusion characteristics. Prescription of the oscillatory instrumental bronchial clearance technique: type of device, starting intensity, intensity progression, sessions per day/time per week, number of weeks, session duration. Evaluation of the effect of the oscillatory instrumental bronchial clearance techniques. The objective was to verify whether the articles met the inclusion criteria, taking into account the title and abstract. Finally, in phase 2, it was taken into account whether it is duplicated yes/no, included yes/no, reason for exclusion and scale to be used to evaluate the quality of the articles, with the following tables: Methodological quality of prospective longitudinal observational studies (Minor's scale). Methodological quality of the controlled clinical trials studies (PEDro scale).

Heterogeneous variation may occur in the outcome measures currently used in COPD research. Therefore, a narrative synthesis of the included study designs was performed, with population characteristics, number of participants in each study, databases, language, and study variables.

Results

The literature review allowed the registration of 3906 studies from the five databases mentioned, 1250 records were eliminated before the duplicate choice phase where it was limited between the period 2013 -2023, in total 2656 records were evaluated by title and abstract where 2598 were excluded for not meeting the inclusion criteria, leaving 58 studies for reading in full text, of which 42 studies were not retrieved, of the 16 studies evaluated in full text for eligibility 2 were excluded. A total of 14 articles were selected for analysis in this systematic review (Figure 1).

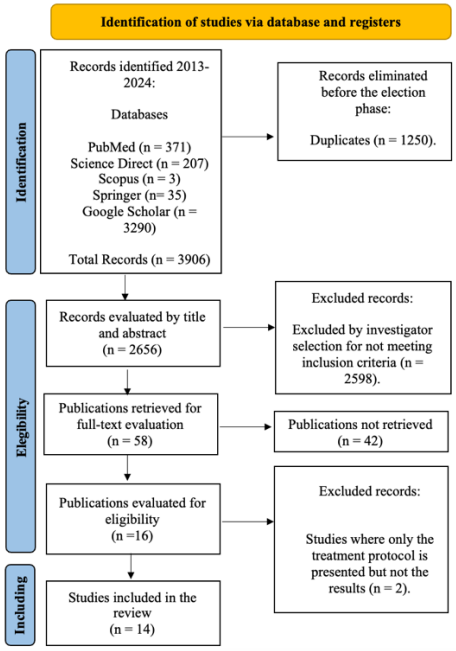

Figure 1. Prisma Flow Diagram

Characteristics of the bibliography

Of the 14 included studies 50% n= (7) were found in the Pubmed database and the remaining 50% in Google Scholar n= (7). Among them ten Controlled Clinical Trial (CCT) 71.4 % n= (10) and four Cohort Studies, (CS) 28.6% n= (4). From the Asian continent 50% n= (7), followed by European with 21% n= (3). In English language 100% n= (14) (Table 1).

Table 1.
Characteristics of the bibliography

#	Authors	Title	Database	Journal	Type of study	Country	Continent	Language	Year	Objetive
1	Gastalldi, et al., (2015)	Oscillating Positive Expiratory Pressure on Respiratory Resistance in Low Secretion COPD	Academic Google	Medicine	CCT	Brazil	America	English	2015	To evaluate the acute effects of an oscillating positive expiratory pressure (Flutter®) device on airway resistance in patients with COPD.
2	Goktalay, et al., (2013)	Does high-frequency chest wall oscillation treatment have any impact on infectious exacerbations of COPD? A single-blind randomized controlled study	Pubmed	Clinical Rehabilitation	CCT	Turkey	Asia	English	2013	To investigate the impact of high- frequency chest wall oscillation in COPD patients with infectious exacerbation.
3	Cheng, et al.,(2022)	Effects of HFCWO expectoration on pulmonary rehabilitation system and cortisol function in patients with severe COPD	Pubmed	Disease Markers	CCT	China	Asia	English	2022	To investigate the effect of the HFCWO system on cortisol rehabilitation and function in patients with severe acute exacerbation of COPD.
4	Nicolini, et al.,(2018)	Safety and efficacy of high-frequency versus percussive ventilation in patients with severe COPD	Pubmed	International Journal of COPD	CCT	Italy	Europe	English	2018	Test the hypothesis that adding IPV and HFCWO may provide additional clinical benefit over chest physiotherapy in patients with severe COPD.
5	Li, et al.,(2023)	Efficacy and safety analysis of piperacillin tazobactam in combination with HFCWO in patients with COPD in conjunction with pneumonia	Pubmed	Alternative Therapies in Health and Medicine	CCT	China	Asia	English	2023	To investigate the efficacy and safety of piperacillin tazobactam in combination with the use of HFCWO to produce expectoration for the treatment of pneumonia in COPD patients and to provide a reference

											for clinical management.
6	O'Sullivan, et al.,)2021)	An initial evaluation of the safety of a disposable oscillating positive expiratory pressure device in chronic COPD patients: a short-term pilot study	Pubmed	BMC Pulmonary Medicine	CS	Ireland	Europe	English	2021	It seeks to evaluate the initial safety of the device and collect usability data on the design.
7	Gupta, et al.,(2022)	Therapeutic efficacy of HFCWO in stable COPD	Pubmed	Lung India	CCT	India	Asia	English	2022	To evaluate the effect of OPEC. therapy in patients with COPD.
8	Farag, et al.,(2018)	To evaluate the effect of HFCWO therapy in patients with COPD.	Academic Google	International Journal of Research in Medical Sciences	CCT	Egypt	Africa	English	2018	To evaluate the efficacy of the HFCWO vest system and Flutter devices in the treatment of COPD patients and also to compare the efficacy of the HFCWO vest system versus Flutter® devices.
9	Mohamed, et al.,(2019)	Intrathoracic vs. extrathoracic oscillations in COPD	Academic Google	Journal of Advanced Pharmacy Education and Research	CCT	Egypt	Africa	English	2019	To compare the efficacy of intra versus extrathoracic oscillations in patients with COPD.
10	Leemans, et al.,(2020)	A functional respiratory imaging approach to the effect of an oscillating positive expiratory pressure device in COPD	Academic Google	International Journal of Chronic Obstructive Pulmonary Disease	CS	Belgium	Europe	English	2020	To analyze the impact of a specific device OPEP, Aerobika®, in addition to standard of care medication on lung dynamics and drug deposition in COPD patients.
11	Tse, et al.,(2020)	Impact of oscillating positive expiratory pressure device use on post-discharge hospitalizations: a retrospective cohort study comparing patients with COPD or chronic bronchitis using Aerobika® and Acapella® devices	Academic Google	International Journal of Chronic Obstructive Pulmonary Disease	CS	Canada	America	English	2020	To compared real world resource use and disease exacerbation among patients with COPD or chronic bronchitis prescribed either of two commonly used OPEP devices.
12	Jahan, et al.,(2015)	Comparison of the effects of the Flutter® device versus autogenous drainage on peak expiratory flow, oxygen saturation, respiratory rate and pulse rate in COPD patients	Pubmed	Journal of Novel Physiotherapy and Physical Rehabilitation	CCT	India	Asia	English	2015	To evaluate the short-term treatment effects of the Flutter® device and autogenous drainage in patients with COPD.
13	Jaiyson, et al.,(2017)	To compare the effects of Acapella® and diaphragmatic breathing exercise in COPD patients	Academic Google	International Journal of Current Research	CCT	India	Asia	English	2017	To investigate the effects of Acapella® and diaphragmatic breathing exercise in COPD patients.
14	Jaiswal, et al.,(2019)	Efficacy of Acapella®, Flutter® and CABT on lung function in COPD patients: A comparative study	Academic Google	Indian Journal of Physiotherapy and Occupational Therapy	CS	India	Asia	English	2019	To compare the efficacy of the CABT technique, Flutter® and Acapella®.

Abbreviations: Chronic Obstructive Pulmonary Disease (COPD), High Frequency Chest Wall Oscillation (HFCWO), Percussive Intrapulmonary Ventilation (IPV), Controlled Clinical Trial (CCT), Cohort Study (CS), Positive Oscillatory Expiratory Pressure (OPEP), Active Breathing Cycle (CABT)

General characteristics of the patients

The total number of participants was 3105, ranging in age from 35 to 85 years. In relation to the gender of the participants of the included studies and despite the fact that the research by Gastalldi, et al., (2015), Jaiyson, et al., (2018) and Jaiswal, et al., (2019) did not specify gender and that in the study by Mohamed, et al., (2019) only participants of male gender were included, 50.2%(n=1519) of the participants were of female gender. The BMI of the patients was between 19.1 and 32.0 (kg/m2). The inclusion criteria were smoking history, COPD GOLD 3-4 and able to cooperate while exclusion criteria were hemodynamic instability, pneumothorax, chest wall trauma, asthma, hemoptysis, any active exacerbation, severe cardiac arrhythmias, bronchiectasis, osteoporosis and presence of malignant disease (table 2).

Table 2.
General characteristics of the patients

#	First author, year	n	F/M	EG/CG	Age (years)	BMI (kg/m2)	Inclusion characteristics	Exclusion characteristics
1	Gastalldi, et al., (2015)	15	NS	EG1= 8 EG2= 7	67.3±9.1	24.9 ± 4.3	Smoking history. Attended clinical laboratory for 4 study visits.	Upper respiratory tract infection. Antibiotic treatment in the 4 weeks prior to the study. Acute dyspnea or hemoptysis. Recent history of rib fracture or pneumothorax.
2	Goktalay, et al., (2013)	50	F=1 M=49	EG= 25 CG=25	65.06 (7.39) (range 45–80)	NS	COPD GOLD 3-4	Need for mechanical ventilation. Bronchiectasis. Active lung tuberculosis. Chest wall trauma. Thoracic or abdominal surgery. Pulmonary embolism. Myocardial infarction.
3	Cheng, et al.,(2022)	65	F= 21 M=44	EG= 33 CG= 32	EG= 67,36 ± 5,95 CG= 68,03 ± 4,76	NS	COPD-related criteria confirmed by clinical and imaging diagnosis. Age > 18 years.	Organic lesions. Fractures. Large amounts of visible pus in the chest.

							Clear consciousness and normal reading and writing. Able to cooperate with the treatment and examination. No more than 10 days of acute exacerbation. Reported and signed the consent form.	Presence of primary adrenal lesions or other endocrine symptoms. Pulmonary embolism. Bronchiectasis. Malignancy. Blood coagulation disorders. Lack of immunity.
4	Nicolini, et al.,(2018)	63	F=28 M=35	CC= 22 GIPV= 20 GHCWO=21	CG= 74.9±2.7 GIPV=72.8±6.1 GHCWO=73.8±5.9	CG= 25.9±3.7 GIPV=25.8±4.3 GHCWO=24.9±5.8	Minimum age of 35 years. GOLD stage 3-4. Bronchial hypersecretion. Effective cough.	Exacerbation of COPD or hospitalization for COPD in the 8 weeks prior to recruitment. Bronchial asthma. Bronchiectasis. Tracheostomy. Mechanical ventilation. Pneumothorax. Severe cardiac arrhythmias. Hemodynamic instability.
5	Li, et al.,(2023)	92	F=58 M=34	EG=46 CG=46	EG=59.32±12.09 CG=59.29±12.06	NS	Meet diagnostic criteria for COPD. Audible over-aggregate sounds on lung auscultation. Elevated leukocyte or neutrophil counts on laboratory tests. Chest x-ray findings of increased texture or infiltrative inflammatory lesions in both lungs. Have not inhaled or taken glucocorticoids in the month prior to the study. Have no contraindications to the use of a sputum ejector.	Having other inflammatory diseases in combination with COPD and pneumonia. Lung cancer. AIDS. Sepsis or other serious infectious diseases in combination with COPD and pneumonia.
6	O'Sullivan, et al.,)2021)	24	F=9 M=15	CG= 24	67,5 (range 53-85)	NS	That the patient was clinically stable at the time of recruitment, was productive and was not currently using an OPEP device.	Any active exacerbation.
7	Gupta, et al.,(2022)	50	F=9 M=41	EG=25 CG=25	EG=69±11.1 CG=61.6±11.1	NS	COPD patients in groups C and D diagnosed according to GOLD guidelines who were clinically stable during the last month.	History of exacerbation in the last month. Hemoptysis. Rib fracture. Pneumothorax. Right and left cardiac decompensation and infection.
8	Farag, et al.,(2018)	108	F=32 M=76	EG HFCWO= 37 EG Fluter®=35 CG= 36	EG HFCWO= 64.0 ± 2.4 EG Flutter®= 60.9 ± 1.6 CG= 63.7 ± 2.1	EG HFCWO= 27.99±6.25 EG Flutter®= 28.46 ±3.61 CG= 27.8 ±2.7	Diagnosis of COPD according to the criteria established by GOLD. Presenting clinical symptoms of exacerbation (increased dyspnea, increased cough and sputum production, altered sputum color and/or viscosity, constitutional manifestations).	Patients with pulmonary disease other than COPD. Any significant musculoskeletal disorder. Osteoporosis. Hiatal hernia. Hemoptysis. Pneumothorax. Acute illness.
9	Mohamed, et al.,(2019)	60	M=60	EG1=30 EG2=30	EG1= 57.10 ±7.08 EG2= 54.67 ±6.17	EG1= 24.88 ±2.49 EG2= 25.89 ±2.09	All patients were diagnosed by a chest physician based on the modified criteria defined in the GOLD guidelines for COPD.	Osteoporosis. Significant gastroesophageal reflux. Hiatal hernia. Recent acute cardiac event or congestive heart failure. Any significant musculoskeletal disorder. Hemoptysis. Presence of malignant disease.
10	Leemans, et al.,(2020)	10	F= 3 M=7	EG Aerobika®=10	67,30 ± 9,63	NS	Age between ≥ 40 and ≤ 85 years. Documented diagnosis of COPD with GOLD 2 to 4 severity according to GOLD guidelines. Cooperative attitude and ability to be trained to correctly use the Aerobika device. Ability to produce sputum. Ability to understand and complete the protocol requirements, instructions and restrictions established by the protocol. Smoking status unchanged within three months after the start of the study and throughout the study period.	Pregnancy or lactation. Unresolved respiratory tract infection. Onset of an exacerbation. Inability to tolerate increased work of breathing. Clinical history of cerebrovascular disease or esophageal surgery. Clinically significant hemodynamic instability. Recent facial, oral or skull surgery or trauma. Active acute sinusitis, epistaxis, hemoptysis or asthma.
11	Tse, et al.,(2020)	2476	F= 1349 M=1127	EG Aerobika®= 619 EG Acapella® =1857	EG Aerobika®= 72.5 EG Acapella®= 71.8	NS	Patients with any evidence of OPEP device use. Adult patients had to have at least one diagnosis of COPD or chronic bronchitis.	Evidence of the index OPEP device in the baseline period, non-index OPEP devices in the follow-up period (including the index date). Asthma. OPEP device use in a postoperative setting.

12	Jahan, et al.,(2015)	30	F=9 M=21	EG Flutter®= 15 EG AD= 15	40-60	NS	Patients with moderate to severe COPD.	Pneumothorax. Hemoptysis. Neuromuscular and cardiovascular disorders. Acute exacerbation of COPD. Acute myocardial infarction. Respiratory failure. Congestive heart failure. Recently undergone thoracic and abdominal surgeries. Restrictive pulmonary disease. Hemodynamic instability. Patients who were uncooperative.
13	Jaiyson, et al.,(2017)	20	NS	EG Acapella®= 10 EG DBE= 10	40-60	NS	Current smokers (40-60) years old men. Known history of COPD. Dyspnea on exertion, persistent wheezing.	Fatigue or respiratory failure. Altered mental status.
14	Jaiswal, et al.,(2019)	42	NS	CG ABCT = 9 EG1 Flutter®= 14 EG2 Acapella®= 19	35-80	NS	Patient with 10-15 years of smoking history. Age criteria of 35-80 years. Patients meeting GOLD criteria for mild and moderate COPD, where FEV1/FVC after bronchodilator ranges from 30-80%. MRC scale grade 1 and grade 2.	Infectious lung disease. Subjects with dyspnea with grade 4 and grade 5. Patients with restrictive lung disease.

Abbreviations: Not Specified (NS), Experimental Group (EG), Control Group (CG), Global Initiative on Obstructive Lung Disease (GOLD), Diabetes Mellitus (DM), Group High Frequency Chest Wall Oscillation (GHFCWO), Group Intrapulmonary Percussive Ventilation (GIPV), Oscillatory Positive Pressure (OPEP), Chronic Obstructive Pulmonary Disease (COPD), Active Breathing Cycle (ABCT), Autogenous Drainage (AD), Diaphragmatic Breathing Exercise (DBE) Forced Expiratory Volume in the First Second (FEV1) Forced Vital Capacity (FVC) Medical Research Council (MRC).

Description of the interventions

Among the devices used, High Frequency Chest Wall Oscillation of (HFCWO) was implemented 35.7% n= (5), followed by Flutter® 28.6% n= (4), Acapella® n= (3) and Aerobika® n= (3) with equal proportion 21.4%. Also, other types of chest physiotherapy interventions such as autogenous drainage, diaphragmatic breathing exercise and active breathing cycle were used. The prescription of the Flutter® device was carried out 1 to 4 times a day, 3 to 5 times a week, with a total duration of 1 to 4 weeks, and each session had a duration of 12 to 20 minutes (Gastalldi, et al.,2015), (S.Farag, et al.,2017), (Jahan, et al.,2015), (Jaiswal, et al.,2019).

In relation to HFCWO, it was applied at an intensity of 10 to 20 Hz, with a frequency that varied from 1 to 3 times a day; as for the number of times per week, only the study by Goktalay, et al., (2013) specified a weekly frequency of 5 times. The duration of the sessions ranged from 20 to 30 minutes, and the total duration of treatment ranged from 1 to 4 weeks (Goktalay, et al., 2013), (Cheng, et al.,2022), (Li, et al.,2023), (S.Farag, et al.,2017). Regarding the prescription of the Acapella device, the study by Jayson, et al., (2018) mentions an intensity of 10 to 20 breaths, 3-4 huffs for eight weeks, while Jaiswal, et al., (2019) describes performing 5 normal respiratory cycles and 5 long, slow, deep breaths, 3 times per week.

Regarding the Aerobika® device, detailed information on the prescription was found in the study by Gupta, et al., (2022), which indicated once a day, three times a week, for 12 weeks, with a session duration of 15 minutes. The study by Leemans, et al., (2020) only specified once a day for two weeks, while Tse, et al., (2020) did not present detailed information on any specific prescription.

Evaluation of the effect of oscillatory instrumental bronchial clearance techniques

The results of the effect of pulmonary function, oxygenation, sputum production, exacerbations, quality of life and aerobic capacity are presented in Table 3. The main findings are detailed below.

Pulmonary function

71% n= (10) of the studies performed FVC assessment. In percentage, baseline values ranged from 55.24±6.93 and 70.9±7.5 and later values ranged from 64.55±6.72 and 109.0±17.5. In liters the baseline values were 1.989±0.839 and 3.52±1.16 and later values were 2.1±0.8 and 3.54±1.25. The 92.8% n= (13) evaluated FEV1. In percentage the baseline values ranged between 30±8.93 and 67.0±17.3 and later between 32±12.48 and 65.3±14.6. In liters the base values ranged between 0.91±0.11 and 1.6 and later between 1.195±0.618 and 2.0. The 50% n= (7) evaluated the FEV1/FVC ratio. Baseline values ranged from 46.13±2.85 and 57.5±11.9 and later values were 49.7±10.8 and 87.36±10.96.

Oxygenation

50% n= (7) of the studies performed evaluation of oxygenation parameters, SaO2, and PaO2 were measured. 5 studies found SaO2 in percentage with baseline values between 80 and 94.20±5.955 and later between 88±6.71 and 97.6 ± 0.4. In 5 studies PaO2 was with baseline values between 45.9±5.4 and 71.8±10.4 and post-intervention between 47.9 ± 4.8 and 89.30±8.52.

Sputum production

The study by Gastaldi, et al., (2015) was the only one that described the volume of expectoration secretion in grams (g),

presenting in COPD patients larger secretion volumes with Flutter exercises 2.54±1.39 g compared to the intervention with sham Flutter® 1.5±1.33 g, P<0.05.

Exacerbations

The study by Gupta, et al., (2022) evaluated the number of exacerbations, with a baseline value of 14(56%) and a subsequent value of 4(16%) P=0.19. Tse, et al., (2020) established the number of moderate and severe exacerbations at 30 days and 12 months later with the Acapella® and Aerobika® devices.

Quality of life

Quality of life was assessed by authors O'Sullivan et al., (2021) and Gupta et al., (2022) with the Saint George Respiratory Questionnaire (SGRQ) with baseline values between 35.5±16.8 and 42.07±15.60 and later values between 24.4±17.0 and 42.80±13.01. Goktalay et al., (2013) and S. Farag et al., (2017) used the BODE index with base values between 4.0± 5.5 and 7.72±1.76 and later between 3.0± 4.5 and 7.24±1.83.

Aerobic capacity

28.57% n= (4) of the studies performed aerobic capacity assessment using the 6 Minute Walk Test (6MWT) measured in meters with baseline values ranging from 133 to 404.72±119.43 and subsequent values ranging from 208 to 431.27±118.90.

Table 3.
Evaluation of the effect of oscillatory instrumental bronchial clearance techniques.

#	First author, year	Measurements	Basal	Posterior
1	Gastalldi, et al., (2015))	FeNO (ppb)	EG= 40.5±29.9 CG=39.3±33.7 Flutter® exercises + pretreatment with bronchodilators= 32.3 ± 29.4 y 31.7 ± 32.0	EG=44.4±33.7 CG 43.6±33.2. No significant differences
		FVC (%)	Placebo Flutter®= 109.8±19.6 Flutter® Exercises= 109.4±18.4 Flutter® + Bronchodilator= 105.8±16.2	109.0±17.5* 107.3 ±18.1* 102.1±18.0*
		FEV1 (%)	Placebo Flutter®= 67.0±17.3 Flutter® Exercises= 67.6±17.7 Flutter® + Bronchodilator= 62.1±16.7	65.3±14.6* 66.0±15.5* 60.3±17.1*
		FEV1/FVC (%)	Placebo Flutter®= 50.3±12.0 Flutter® Exercises= 51.0±13.0 Flutter® + Bronchodilator= 48.5 ± 12.8	49.7±10.8* 51.0±12.5* 48.9 ± 12.8*
		FEF 25-75 (%)	Placebo Flutter®= 17.8±6.8 Flutter® Exercises= 18.93±8.0 Flutter®+ Bronchodilator= 15.7±6.4	17.6±6.9* 18.0±7.1* 15.1±7.0*
		IOS R5 (kPa/L/s) Breath	Flutter®= 0.63±0.16 Flutter® + Bronchodilator= 0.61±0.28	0.61±0.18 P<0.05 0.56±0.24 P<0.05
		IOS R5 (kPa/L/s) Inspiration	Flutter®= 0.52±0.12 Flutter® + Bronchodilator= 0.46±0.16	0.50±0.11 P<0.05 0.45±0.15 P<0.05
		IOS R5 (kPa/L/s) Expiration	Flutter®= 0.73±0.21 Flutter® + Bronchodilator= 0.72±0.36	0.70±0.25 P<0.05 0.65±0.32 P<0.05
		IOS R20 (kPa/L/s)	Flutter®= 0.42±0.12 Flutter® + Bronchodilator= 0.41±0.15	0.41±0.15 P<0.05 0.39±0.14 P<0.05
		Volume of secretion expectoration (g)	Exercise secretions with Flutter®= 2.54±1.39 Secretions in Flutter®-Placebo= 1.5±1.33 Cough = Flutter® + Bronchodilator (3.95 and 3.63 cough, respectively) Cough= Flutter® - Placebo intervention (1.69 cough	COPD patients had significantly higher secretion volumes with Flutter® exercises 2.54±1.39 compared to Flutter® - Placebo intervention 1.5±1.33 P<0.05. There was no difference between the purulence score Placebo= 2.57±0.79; Flutter®= 2.30±0.82; Flutter® + Bronchodilator= 2.60±1.34.
2	Goktalay, et al., (2013)	FEV1 (%)	Day 0 EG=30±8.93 CG=28±8.95 P=0.676	Day 3 EG= 32±12.48 CG= 32±9.91 P=0.838 Day 5 EG= 33±11.05 CG=33±10.53 P=0.734
		MMRC	Day 0 EG=3.36±0.90 CG =3.32±0.90 P=0.726	Day 3 EG= 3.36±0.90 CG=3.28±0.84 P=0.625 Day 5 EG=3.28±0.89 CG=3.04±0.88 P=0.268
		TM6M (M)	Day 0 EG=133 CG=145 P=0.938	Day 3 EG= 174 CG=218 P=0.294 Day 5 EG= 208 CG=264 P=0.174
		BODE Index	Day 0 EG=7.72±1.76 CG=7.72±1.89 P=0.554	Day 3 EG=7.48±1.78 CG=7.00±2.21 P=0.408 Day 5 EG= 7.24±1.83 CG=6.44±2.46 P=0.186
		pH	Day 0 EG=7.39±0.04 CG=7.37±0.09 P=0.869	Day 3 EG=7.40±0.03 CG=7.40±0.03 P=0.578 Day 5 EG=7.40±0.03 CG=7.39±0.03 P=0.984
		PaO2 (mmHg)	Day 0 EG=53±13.44 CG=53±10.40 P=0.641	Day 3 EG=59±12.53 CG= 61±10.54 P=0.260 Day 5 EG= 64±14.06 CG=7.39±0.03 P=0.984
		PaCO2 (mmHg)	Day 0 EG=49±14.76 CG=50±12.77 P=0.823	Day 3 EG=47±10.68 CG= 48±7.91 P=0.683 Day 5 EG= 46±9.26 CG=46±7.24 P=0.930
		SaO2 (%)	Day 0 EG=83±12.03 CG=83±8.93 P=0.403	Day 3 EG=88±6.71 CG= 89±6.25 P=0.689 Day 5 EG= 90±5.15 CG=90±4.63 P=0.689
3	Cheng, et al.,(2022)	PaO2 (mmHg)	EG=71.06±9.85 CG= 70.75±10.70 P=0.903	EG= 89.30±8.52 CG= 82.94±7.82 P=0.003
		PaCO2 (mmHg)	EG= 61.85±6.66 CG= 61.56±7.68 P=0.873	EG= 44.06±5.81 CG= 48.06±5.98 P=0.008
		FVC (%)	EG= 55.24±6.93 CG= 55.25±6.62 P=0.996	EG= 64.55±6.72 CG= 60.41±5.99 P=0.011
		FEV1 (%)	EG= 37.88±8.43 CG=38.19±6.58 P=0.870	EG= 48.03±7.04 CG= 43.81±6.28 P=0.013
		FEV1/FVC (%)	EG= 54.36±4.71 CG=55.28±4.95 P=0.446	EG= 87.36±10.96 CG=80.47±7.86 P=0.005
		WBC (×109/L)	EG= 11.07±2.28 CG= 11.78±3.21 P=0.305	EG= 6.42±1.54 CG= 8.26±1.66 P=<0.001
		PCR (mg/L)	EG= 21.33±7.38 CG= 23.54±6.89 P=0.217	EG= 5.80±1.36 CG= 10.11±3.08 P=<0.001
		IL-6 (pg/mL)	EG= 180.27±30.05 CG= 180.80±34,47 P=0.947	EG= 89.62±17.58 CG=102.03±14.19 P=0.003
		COR (nmol/L)	EG= 435.15±56.59 CG= 437.93±45.31 P=0.828	EG= 175.43±39.39 CG= 203.36±40.19 P=0.006
		ACTH (pg/mL)	EG= 64.60±7.93 CG= 63.25±9.65 P=0.539	GE= 39.62±6.54 GC= 44.12±8.95 P=0.024
4	Nicolini, et al.,(2018)	CAT Index	CG= 23.7±7.4 IPV=24.7±5.9 HFCWO= 24.9±6.4	CG= 26.9±7.6 IPV=17.0±6.3 P<0.001 HFCWO= 20.9±6.9 P<0.001

		MMRC	CG= 3.1±0.8 IPV=2.7±0.9 HFCWO= 2.5±1.0	CG= 3.2±0.8 IPV=2.4±0.9 P=0.01 HFCWO= 2.4±0.9 P=0.04
		WBC (×109/L)	CG= 8.033±1.749 IPV=7.938±1.886 HFCWO= 7.433±2.028	CG= 9.335±1.558 IPV=7.519±1.907 P<0.001 HFCWO= 7.155±1.755 P<0.001
		PCR (mg/L)	CG= 0.5±0.5 IPV=1.0±0.7 HFCWO= 1.5±1.7	CG= 0.8±0.5 IPV= 0.6±0.4 P<0.001 HFCWO= 0.9±0.9 P<0.001
		FVC (L)	CG= 2.609±0.738 IPV= 1.989±0.839 HFCWO= 2.078±0.701	CG= 2.414±0.919 IPV= 2.256±0.804 P<0.001 HCFWO= 2.269±0.633 P<0.001
		FVC (%)	CG= 65±10 IPV= 60±16 HFCWO= 66±12	CG= 59±12 IPV= 68±13 P<0.001 HFCWO= 71±9 P<0.001
		FEV1 (L)	CG= 1.155±0.504 IPV= 1.013±0.568 HFCWO= 1.236±0.543	CG= 1.045±0.446 IPV= 1.195±0.618 P<0.001 HFCWO= 1.349±0.554 P<0.001
		FEV1 (%)	CG= 35±9 IPV= 37±12 HFCWO= 43±11	CG= 31±9 IPV= 44.0±2.1 P<0.001 HFCWO= 45.7±3.6 P<0.001
		FEV1/FVC (%)	CG= 45.6±13.4 IPV= 48.8±13.0 HFCWO= 57.5±11,9	CG= 43.9±12.2 IPV= 51.8±11.0 P=0.04 HFCWO= 58.8±13,4 P=0.02
		TLC (L)	CG= 5.799±1.347 IPV= 73.81±2.047 HFCWO= 5.458±1.426	CG= 5.847±1.024 IPV= 5.859±1.168 P=0.01 HFCWO= 5.247±1.355 P=0.04
		TLC (%)	CG= 139±21 IPV= 147±31 HFCWO= 133±35	CG=145±18 IPV= 137±23 P=0.01 HFCWO= 124±28 P=0.04
		RV (L)	CG= 3.731±0.758 IPV= 4.106±1.805 HFCWO= 3.453±1.296	CG= 3.781±718 IPV= 3.708±1.173 P=0.02 HFCWO= 3.299±1.153 P=0.02
		RV (%)	CG= 190±67 IPV= 183±66 HFCWO= 146±37	CG=203±66 IPV= 150±36 P=0.02 HFCWO= 136±29 P=0.02
		RV/TLC (%)	CG= 65.1±9.7 IPV= 67.0±13.5 HFCWO= 59.6±97	CG= 67.9±13.0 IPV= 63.6±8.1 P=0.01 HFCWO= 60.5±9.7 P=0.01
		DLCO%	CG= 51.0±5.7 IPV= 60.6±15.0 HFCWO= 67.5±12.3	CG= 48.5±14.1 IPV= 67.8±9.1 P<0.001 HFCWO= 69.7±5.7 P<0.001
		MIP (kPa)	CG= 5.8±2.1 IPV= 6.2±2.0 HFCWO= 6.8±2.3	CG= 5.3±1.8 IPV= 8.1±2.0 P<0.001 HFCWO= 7.5±2.8 P= 0.004
		MEP (kPa)	CG= 6.4±2.4 IPV= 7.4±1.9 HFCWO= 7.2±2.1	CG= 5.8±2.0 IPV= 9.3±1.4 P<0.001 HFCWO=8.0±2.4 P<0.001
		PaO2 (mmHg)	CG= 69.1±10.1 IPV= 71.8±7.8 HFCWO= 71.8±10.4	CG= 67.9±9.5 IPV= 76.3±6.3 P<0.001 HFCWO= 74.8±9.6 P<0.001
		PaCO2 (mmHg)	CG= 42.0±5.3 IPV= 42.5±4.8 HFCWO= 41.7±3.9	CG= 43.1±6.9 IPV= 40.4±3.1 P= 0.003 HFCWO= 40.3±3.7 P= 0.004
		HCO3	CG= 24.3±1.2 IPV= 23.6±2.0 HFCWO= 24.4±1.8	CG= 24.0±1.3 IPV= 23.4±1.8 P= 0.07 HFCWO= 23.9±2.1 P= 0.08
5	Li, et al.,(2023)	FEV1 (L)	CG= 1.6 EG= 1.6	CG= 1.8 EG=2.0 P<0.0001
		FVC (L)	CG= 1.9 EG= 2.0	CG= 2.2 EG= 2.7 P<0.0001
		FEV1 (%)	CG= 32 EG= 30	CG= 40 EG= 45 P<0.001
		FEV1/FVC (%)	CG= 50 EG= 50	CG= 58 EG= 63 P<0.0001
		PaCO2 (mmHg)	CG= 55 EG= 55	CG= 45 EG= 40 P<0.05
		PaO2 (mmHg)	CG= 55 EG= 55	CG= 65 EG= 70 P<0.0001
		SaO2 (%)	CG= 80 EG= 80	CG= 85 EG= 90 P<0.0001
		IL-2	CG= 4.0 EG= 3.9	CG= 5.0 EG= 6.2 P<0.0001
		IL-10	CG= 3.2 EG= 3.3	CG= 4.0 EG= 5.0 P<0.0001
		TNF-a	CG= 3.5 EG= 3.6	CG= 1.5 EG= 1.0 P<0.0001
		PCR	CG= 110 EG= 110	CG= 50 EG= 48 P<0.01
		PCT	CG= 1.1 EG= 1.1	CG= 0.8 EG= 0.2 P<0.05
6	O'Sullivan, et al.,)2021)	FEV1 (L)	1.41 SD=0.66	1.46 SD=0.74 P=0.163
		FVC (L)	2.74 SD = 0.86	2.76 SD=0.86 P=0.779
		6MWT (M)	404.72 SD=119.43	431.27 SD=118.90 P=0.124.
		SaO2 (%)	93.05 SD=3.03	92.84 SD=2.91 P=0.702
		SGRQ	42.07 SD= 15.60	42.80 SD=13.01 P=0.733
7	Gupta, et al.,(2022)	FEV1 (L)	EG= 1.1±0.4 CG= 1.1±0.5 P=0.6	EG= 1.2±0.4 P< 0.001 CG= 1.1±0.5 P=0.83
		FVC (L)	EG= 2.0±0.8 CG= 2.0±0.7 P=0.8	EG= 2.1±0.8 P= 0.004 CG= 2.0±0.7 P=0.01
		6MWT (M)	EG= 343±82 CG= 313±104 P=0.06	GE= 358±74 P= 0.08 GC= 311±103 P=0.69
		SGRQ	EG= 35.5±16.8 CG= 62.6±23.0 P<0.001	EG= 24.4±17.0 P<0.001 CG= 52.9±22.8 P<0.001
		CAT Index	EG= 12,3±5,6 CG= 11,8±5,2 P=0.8	EG= 11,2±4,8 P< 0.001 CG= 11,8±5,1 P=1
		Number of exacerbations (%)	EG= 14 (56%) CG= 13 (52%) P=1	EG= 4 (16%) P=0.19 CG= 9 (36%)
8	Farag, et al.,(2018)	FEV1 (%)	HFCWO= 44.8±0.8 Flutter®= 43.8±0.8 P= CG= 45.8±1.6	HFCWO= 53.4±5.3 P=0.002 Flutter®= 52.2±4.9 P=0.003 CG= 52.6±2.1 P=0.055
		FVC (%)	HFCWO= 60.7± 11.6 Flutter®= 70.9±7.5 CG= 69.4±6.9	HFCWO= 72.3± 5.1 P=0.003 Flutter®= 76.6±9.0 P=0.019 CG= 71.7±8.0 P=0.07
		FEV1/FVC (%)	HFCWO= 53.5±9.8 Flutter®= 54.36±8.8 CG= 55.5±6.7	HFCWO= 56.6± 7.5 P=0.023 Flutter®= 57.5 ± 8.3 P=0.023 CG= 57. 2 ± 5.9 P=0.056
		FEF 25-75 (%)	HFCWO= 53.4±0.2 Flutter®= 58.5±10.06 CG= 58.4±8.1	HFCWO= 54.12±0.26 P=0.082 Flutter®= 54.6±12.5 P=0.27 CG= 59.0±10.2 P=0.3
		pH	HFCWO= 7.36±0.01 Flutter®= 7.4±0.03 CG= 7.35±0.04	HFCWO= 7.35±0.1 P=0.37 Flutter®= 7.45±0.2 P=0.063 CG= 7.44±0.1 P=0.07
		PaCO2 (mmHg)	HFCWO= 46.2±3.7 Flutter®= 46.8±4.4 CG= 45.9±5.4	HFCWO= 47.9±4.8 P=0.56 Flutter®= 48.6±4.2 P=0.48 CG= 45.0±3.5 P=0.51
		PaO2 (mmHg)	HFCWO= 46.2±3.7 Flutter®= 46.8±4.4 CG= 45.9±5.4	HFCWO= 47.9 ± 4.8 P=0.001 Flutter®= 48.6 ± 4.2 P=0.001 CG= 45.0 ± 3.5 P=0.02
		SaO2 (%)	HFCWO= 89.1±3.0 Flutter®= 85.7±3.8 CG= 83.4±2.2	HFCWO= 94.3±1.0 P=0.002 Flutter®= 97.6±0.4 P=0.001 CG= 90.7±0.6 P=0.04
		CAT Index	HFCWO= 19.9±7.1 Flutter®= 20.2±7.2 CG= 21.2±6.4	HFCWO= 15.5± 6.3 P=0.003 Flutter®= 16.0±6.2 P=0.005 CG= 19.8±3.3 P=0.055
		BODE Index	HFCWO= 4.0± 5.5 Flutter®= 4.5±1.6 CG= 4.9±1.9	HFCWO= 3.2±0.3 P=0.002 Flutter®= 3.0± 4.5 P=0.001 CG= 4.0±4.48 P=0.06
		MMRC	HFCWO= 3.4±0.9 Flutter®= 3.3±0.9 CG= 4.0±0.9	HFCWO= 2.1±0.7 P=0.001 Flutter®= 2.0±0.9 P=0.002 CG= 3.8±0.9 P=0.07
		6MWT (M)	HFCWO= 208±0.8 Flutter®= 204±0.3 CG= 210±0.1	HFCWO= 269.3±62.9 P=0.000 Flutter®= 258.7±43.4 P=0.008 CG= 221.5±418.3 P=0.08
9	Mohamed, et al.,(2019)	FVC (L)	Quake®= 1.99±0.14 HFCWO=1.99±0.12	Quake®= 2.57±0.18 P<0.001 HFCWO= 2.27±0.14 P<0.001
		FEV1 (L)	Quake®= 0.91±0.11 HFCWO= 0.95±0.12	Quake®= 1.51±0.13 P<0.001 HFCWO= 1.23±0.09 P<0.001
		FEV1/FVC (%)	Quake®= 46.13±2.85 HFCWO= 48.93±2.36	Quake®= 56.81±2.65 P<0.001 HFCWO= 53.63±2.83 P<0.001
		FEF 25-75 (%)	Quake®= 0.51± 0.08 HFCWO= 0.53±0.12	Quake®= 0.91±0.16 P<0.001 HFCWO= 0.74±0.16 P<0.001
		IOS R5 (Hz)	Quake®= 316.54±28.39 HFCWO= 311.78±26.12	Quake®= 247.59±24.54 P<0.001 HFCWO= 246.3±22.81 P<0.001
		IOS X5 (Hz)	Quake®= -0.75±0.11 HFCWO= -0.62±0.12	Quake®= -0.49±0.08 P<0.001 HFCWO= -0.46±0.09 P<0.001
10	Leemans, et al.,(2020)	FVC (L)	3.52±1.16	3.54±1.25 P=0.717
		FEV1 (L)	1.58±0.71	1.59±0.75 P=0.860

		FEP (L/s)	4.92±1.78	4.68±1.76 P=0.071
		TLC (L)	6.30±1.02	6.33±0.99 P=0.639
11	Tse, et al.,(2020)	Number of severe exacerbations per patient	30 days after discharge= Aerobika®= 0.1 SD 0.4 Acapella®= 0.2 SD 0.5 P=0.002	12 months after discharge= Aerobika®= 0.7 SD 1.3 Acapella®= 0.9 SD 1.4 P=0.01
		Number of moderate exacerbations per patient	30 days after discharge= Aerobika®= 0.2 SD 0.5 Acapella®= 0.2 SD 0.6 P=0.37	12 months after discharge= Aerobika®= 1.0 SD 1.8 Acapella®= 1.2 SD 3.2 P=0.03
12	Jahan, et al.,(2015)	PEFR	Flutter®= 142.00± 21.778 AD= 155.00± 52.474	Flutter®= 166.67± 38.110 P=0.0001 AD= 172.67± 54.963 P=0.0001
		SaO2 (%)	Flutter®= 94.20±5.955 AD= 96.07± 3.654	Flutter®= 95.93±4.682 P=0.0001 AD= 96.80±2.957 P=0.0001
		RR (bpr)	Flutter®= 29.07±5.885 AD= 27.67± 6.366	Flutter®= 29.33±5.473 P=0.0001 AD= 28.07±6.181 P=0.0001
		HR (BPM)	Flutter®= 104.13±16.137 AD= 104.33±10.688	Flutter®= 106.40±14.045 P=0.0001 AD= 103.47± 9.913 P=0.0001
13	Jaiyson, et al.,(2017)	FEV1 (%)	EG = 55.70 SD 3.68 CG = 55.30 SD 3.30	EG= 63.90 SD 1.91 P≤ 0.001 CG= 59.40 SD 3.47
14	Jaiswal, et al.,(2019)	FEV1 (L)	ACBT= SD 0.35 Flutter®= SD 0.30 Acapella®=SD 0.32	ACBT= SD 0.38 P=0.000 Flutter®= SD 0.32 P=0.004 Acapella®= SD 0.42 P=0.002
		FVC (L)	ACBT= SD 0.50 Flutter®= SD 0.55 Acapella®= SD 0.60	ACBT= SD 0.50 P=0.000 Flutter®=SD 0.67 P=0.005 Acapella®=SD 0.65 P=0.004
		FEV1/FVC (%)	ACBT= SD 10.40 Flutter®= SD 9.56 Acapella®=SD 8.94	ACBT= SD 10.26 P=0.98 Flutter®= SD 10.54 P=0.12 Acapella®= SD 7.45 P=0.38
		PEFR	ACBT= SD 1.18 Flutter®= SD 1.1.3 Acapella®= SD 1.22	ACBT= SD 1.34 P=0.025 Flutter= SD 1.26 P=0.007 Acapella= SD 1.67 P=0.025
		MEFR	ACBT= SD 0.27 Flutter®= SD 0.23 Acapella®= SD 0.19	ACBT= SD 0.40 P=0.02 Flutter®= SD 0.30 P=0.04 Acapella®= SD 0.29 P=0.24

Abbreviations: * No significant differences, EG: Experimental group, CG: Control group, IPV: Percussive Intrapulmonary Ventilation, HFCWO: High Frequency Oral Oscillation, ACBT: Active Breathing Cycle, AD: Autogenous Drainage, FeNO: Measurement of the fraction of exhaled Nitric Oxide, FVC: Forced Vital Capacity, FEV1: Forced Expiratory Volume in 1 second, IOS: Impulse Oscillometry, 6MWT: 6 Minute Walk Test, MMRC: Modified Medical Advice Dyspnea Scale, BODE Index: Baseline Quality of Life Index, pH: Hydrogenion Potential, PaO2: Partial Blood Oxygen Pressure, PaCO2: Carbon Dioxide Partial Pressure, SaO2: Oxygen saturation, WBC: White Blood Cell Count, IL-6: Interleukin-6, COR: Cortisol, ACTH: Adrenocorticotrophic Hormone, PCR: C Reactive Protein, TLC: Total Lung Capacity, RV: Residual Volume, DLCO: Carbon Monoxide Pulmonary Dilution, MEP: Peak Expiratory Pressure; MIP: Maximum Inspiratory Pressure; HCO3: Bicarbonate, IL-2: Interleukin-2, IL-10: Interleukin-10, NTF-a: Tumor Necrosis Factor Alpha, CAT Index: COPD Screening Test, COPD: Chronic Obstructive Pulmonary Disease, MEFR: Peak Expiratory Flow Rate, FEF 25-75%: Forced Expiratory Flow Radius 25-75%, PEFR: Peak Expiratory Flow Rate, PEF: Peak Expiratory Flow, PCT: Procalcitonin, SGRQ: Saint George Respiratory Questionnaire, SD: Standard Deviation.

Methodological quality of the studies

Of the 14 articles included in this review, 4 articles were evaluated with the Minors scale, which assesses the methodological quality of comparative and noncomparative cohort and case-control studies. This scale includes the following items: (1) Clearly defined objective, (2) Consecutive patient inclusion, (3) Prospective data collection, (4) Appropriate outcomes for the study objective commensurate with intention-to-treat, (5) Unbiased assessment of results (blinding), (6) Follow-up period appropriate for the study objective, (7) Loss to follow-up less than 5%, (8) Study sample size calculation, 95% confidence interval, (9) An adequate control group, (10) Groups managed at the same time both control and study, (11) Baseline equivalence of groups, (12) Adequate statistical analyses. Abbreviations 0 = not reported, 1 = reported but inadequate 2 = reported and adequate. The ideal score would be 16 for non-comparative studies and 24 for comparative studies (Slim et al., 2003). Two studies included in our review were noncomparative studies; according to the interpretation of the scale, the ideal score is 16 for this type of study, of which 2 studies obtained a score above this value.

The remaining 10 articles of this review were evaluated with the PEDro scale, which determines the methodological quality of controlled clinical trial type studies. This scale includes the following items: (1) Choice criteria were specified (*- This item is not used to calculate the PEDro score), (2) Subjects were randomly assigned to groups (in a crossover study, subjects were randomly distributed as they received treatments), (3) Assignment was concealed, (4) Groups were similar at baseline with respect to the most important prognostic indicators, (5) All subjects were blinded, (6) All therapists administering therapy were blinded, (7) All assessors measuring at least one key outcome were blinded, (8) Measures of at least one of the key outcomes were obtained from more than 85% of subjects initially assigned to groups, (9) Results were presented for all subjects who received treatment or were assigned to the control group, or when this could not be, data for at least one key outcome were analyzed by "intention-to-treat", (10) Results of statistical comparisons between groups were reported for at least one key outcome, (11) The study provides point and variability measures for at least one key outcome. Abbreviations 1= item met, 0 = item not met. Quality criteria: ≥ 7 high quality. 5-6 intermediate quality. ≤ 4 low quality (Matos et al.,2020). Our study obtaining a result of 50% n= (5) with high quality, and the remaining 50% n= (5) with intermediate quality.

Discussion

The aim of this systematic review was to summarize the current evidence on the efficacy of oscillatory instrumental bronchial clearance techniques in the treatment of COPD. According to the results of 14 studies with a total of 1519 participants, there is evidence that oscillatory instrumental techniques improve lung function, oxygenation, reduce exacerbations, increase sputum production, improve quality of life and aerobic capacity of patients.

The presence of cough, increased sputum production, dyspnea and respiratory distress are common symptoms in

COPD (Mihaltan et al.,2021). These symptoms can be severe in exacerbation episodes (Ko et al.,2021). Excessive accumulation of secretions in the lungs can lead to more frequent exacerbations, which can lead to decreased quality of life and increased morbidity and mortality (Vogelmeier et al.,2020). Adequate drainage to remove secretions from the airways is important in the treatment of COPD, and deeper drainage of secretions is necessary during exacerbation to alleviate symptoms (Shen et al.,2018). Respiratory physiotherapy techniques of bronchial clearance, oxygen therapy, aerosol therapy and inhalation therapy are common treatment techniques and clinically useful for these patients (Torres-Sanchez et al., 2017). Oscillatory instrumental techniques can help increase sputum clearance (Ribeiro et al.,2020).

The use of HFCWO in our study was employed in the majority of articles, representing 35.7%. The use of HFCWO was shown to have positively affected pulmonary rehabilitation in patients with acute exacerbation of COPD, significantly improving blood gas levels and reducing inflammation (Cheng et al.,2022). These results indicate that the application of HFCWO is safe and feasible in the treatment of severe COPD. In comparison with the use of HCFWO in patients diagnosed with cystic fibrosis, Leemans et al., (2020) point out that a recently developed device, known as the Monarch Airway Clearance System®, which is a portable vest that combines mobility with HFCWO by oscillating eight pulmonary discs over the upper and lower lobes of the lungs, provides an increase in airway clearance and improved secretion transport. This would justify the use of this therapeutic strategy in pathologies other than COPD, where there is also a deficiency in pulmonary mechanics and oxygenation, associated with an increase in bronchial secretions.

Our study describes the prescription of different oscillatory instruments in COPD. However, the prescription of such instruments may vary due to the heterogeneity of pathologies and patients. Çelik et al., (2022), conducted a study in patients with COVID-19 where HFCWO was used for 20 minutes, 2 times a day with a frequency of 8 Hz. In our study these parameters are different, the sessions range from 20 to 30 minutes with a frequency of 10 to 20 Hz and can be implemented up to 3 times a day. In another study by Kim et al., (2023) they used the Aerobika® 2 twice a day with a duration of 10 to 20 minutes for 6 months in patients with bronchiectasis, in this review the dosage of this instrument is similar to the COPD patients in our study, where the time is 15 minutes and it can be used up to 3 months 3 times a day. On the other hand, in the article by Ni et al. (2018), they describe that the Acapella® can be used 5 times a day for at least 5 minutes in pathologies with lower respiratory tract infections. In our study, for the COPD condition its prescription is different, it can be implemented for 8 weeks with sessions of 10 to 20 breaths. Therefore, according to the evidence, it could be said that the use of the instruments is different for each condition, therefore, it is recommended to make an individualized prescription according to the needs of each patient.

Chakravorty et al., (2011) conducted a study of the impact of HFCWO in COPD patients with mucus hypersecretion in which they mentioned that no significant changes were found between FEV1 and FEV1 after the intervention. It is worth mentioning that this study was not included in the analysis of the present review because it was outside the range of the measurement time window. In our study, among the studies that evaluated pulmonary function, some authors reported significant changes in spirometry variables such as FEV1, FVC, FEV1/FVC ratio, CPT, RV. However, other authors did not find significant changes in these variables.

The evaluation of oxygenation parameters in our study was measured by SaO2 and PaO2 parameters. Two authors, Goktalay et al., (2023) and O'Sullivan et al.,(2021), did not show significant changes in these variables. While the remaining studies that included the assessment of oxygenation did show significant changes after the HFCWO intervention.

In our study, quality of life was evaluated by four studies with the SGRQ questionnaires and the BODE index. Significant differences were found in 2 studies. The study by Chakravorty et al., (2011) using the SGRQ questionnaire did show improvement in patients undergoing HFCWO in variables such as mean change in sputum volume. The study by Nonato et al., (2015) uses this questionnaire for airway disease in COPD patients, which has shown that the Saint George Respiratory Questionnaire index serves as an indicator of mortality risk, in addition to providing relevant information on quality of life in the evaluation of COPD patients.

Aerobic capacity was evaluated using the 6MWT, where of the four articles that evaluated this variable only one S.Farag et al., (2017) showed significant differences after intervention with HFCWO. Nevertheless, it is important to emphasize that the 6MWT assessment is a simple tool with scientific validity that, according to the variation in the distance walked in patients, provides independent predictive factors for mortality du Bois et al., (2014). According to the study by Agarwala et al., (2020) a significant correlation has been observed between the distance walked in 6MWT and clinical outcomes in COPD patients, which can be attributed to the fact that 6MWT reflects both pulmonary and extrapulmonary manifestations of the disease.

As limitations of this study, it was found that the articles evaluated lacked precision in describing in detail each of the parameters of the prescription of the devices implemented, including aspects such as: intensity, sessions per day/time per week, number of weeks and duration of the session in minutes. Greater precision would facilitate comparative analysis and provide recommendations with specificity for implementation. Also, it is important to continue to conduct research in the area where the number of patients in the study sample can be expanded to provide more precise estimates of

the results. Moreover, not all the studies reviewed found significant differences in the results, so it is suggested to deepen the study in this field, with more representative samples of patients, to strengthen the scientific evidence to support more accurately the intervention with HFCWO.

To conclude, it is possible to say that this research presents the first review that consolidates the most recent evidence on instrumental oscillatory bronchial clearance techniques in COPD patients, including the effects and their prescription. The scope of this study is broad, as it will provide professionals in the area with a deeper knowledge about HFCWO in COPD, thus promoting the implementation of this evidence-based intervention as an adjunct therapy to manual or conventional chest physiotherapy techniques.

Conclusions

This research shows that oscillatory devices in COPD generate positive effects on pulmonary function (FVC, FEV1), oxygenation (SaO2, PaO2) and can even reduce the number of exacerbations. Although in some of the studies analyzed, no statistically significant differences in the results were observed, possibly related to small patient samples or methodological aspects, which suggests the need for further research to continue evaluating the effectiveness of the devices.

The most frequent instruments such as the HFCWO, Flutter®, Acapella®, Aerobika®, which can be used in in-hospital and outpatient rehabilitation processes, are consolidated.

The prescription varies according to the type of oscillatory device used. However, it was observed that its execution is proposed between 1 to 12 weeks, from 3 to 7 times per week, from 1 to 4 daily sessions, with duration between 10 to 30 minutes, between 10 to 20 Hz. It should be clarified that the prescription should be made on an individual basis, according to the characteristics of each patient.

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