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Comparative Study Of Pulmonary Function Improvement In COPD: HFCWO Vs Manual Chest Physiotherapy

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Abstract

Background: *Chronic Obstructive Pulmonary Disease (COPD) is a leading worldwide cause of morbidity and mortality with persistent airflow limitation, heightened mucus production, and impaired mucociliary clearance. Airway clearance techniques (ACTs) such as High-Frequency Chest Wall Oscillation (HFCWO) and Manual Chest Physiotherapy (CPT) are an integral part of pulmonary rehabilitation, but evidence of comparative effectiveness in improving pulmonary function is limited.*

Objective: *The aim of this study was to compare the impact of HFCWO and manual CPT on pulmonary function parameters among patients with COPD.*

Methods: *Comparative analysis was conducted with independent samples t-tests and effect size estimation. Pulmonary function tests like FEV_1, FVC, and PEFR were assessed between the patients who received either HFCWO or CPT. For statistical significance, effect sizes (Cohen's d, Hedges' correction, Glass's delta) were estimated. Posterior distribution characterizations were also performed to compare intervals of credible mean differences.*

Results: *The findings revealed no statistically significant differences between HFCWO and manual CPT groups on pulmonary function outcomes ($p > 0.05$ for all tests). Small effect sizes, along with confidence intervals that included zero, suggested minimal differences between interventions. Posterior distributions further suggested small differences in means with extremely broad credible intervals.*

Conclusion: *HFCWO and manual CPT were equally effective in improving pulmonary function in COPD patients. Choice of airway clearance strategy should be patient-specific, considering patient preference, availability of resources, and location of care. Further large-scale, long-term studies are required to investigate clinical outcomes other than pulmonary function, including frequency of exacerbations, rates of hospitalization, quality of life, and cost-effectiveness.*

Keywords: *Chronic Obstructive Pulmonary Disease, High-Frequency Chest Wall Oscillation, Manual Chest Physiotherapy, Pulmonary Function, Airway Clearance Techniques*

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is generally recognized to be one of the world's most prevalent and disabling lung diseases and a major cause of morbidity and mortality (PRASAD, 2020). COPD currently affects nearly half a billion individuals, according to the most recent estimates by the World Health Organization (WHO), and is projected to become the third leading cause of global death. The condition is characterized by persistent respiratory symptoms and airflow limitation due to abnormal airway and/or alveolar abnormalities, usually due to prolonged exposure to injurious particles or gases, largely from tobacco smoke and outdoor air pollutants (Barnes, P.J., 2020).

A typical characteristic of COPD pathophysiology is excessive mucus production and concomitant failure of mucociliary clearance. This ultimately results in the persistence of mucoid secretions in the airways and generates airflow limitation, increased work of breathing, frequent infections, and frequent exacerbations (Munkholm, M. and Mortensen, J., 2014). All these pathophysiologic mechanisms not only lead to deteriorating pulmonary function but also marked deterioration in the quality of life of patients, exercise capacity, as well as general health status. Besides, they are a serious economic load on the healthcare system in terms of repeated hospitalization and long-term medical requirements.

For this, airway clearance techniques (ACTs) become the keystone to overall management of COPD in patients with predominant mucus hypersecretion. ACTs are aimed at enhancing mobilization and

expectoration of bronchial secretions, thereby alleviating airflow obstruction, preventing the occurrence of pulmonary infection, and facilitating ventilation and gas exchange (Shah et al., 2023). Amongst the numerous ACTs, High-Frequency Chest Wall Oscillation (HFCWO) and Manual Chest Physiotherapy (CPT) are two of the most frequently utilized interventions, both with varying mechanisms and patterns of operation.

HFCWO is a device-based, mechanical intervention during which external oscillatory forces are delivered to the chest wall through a pneumatic vest system. The device creates rapid compressions at predetermined frequencies, which are passed on to the airways and lungs, dislodging mucus and stimulating its passage into the main airways where it can be expelled through coughing or suction (O'Sullivan, K.J., 2022). One of the appeals of HFCWO is the ability to provide standardized, standardized therapy with minimal human intervention, possibly resulting in increased patient independence, comfort, and compliance, especially in homecare.

Conversely, manual CPT is a set of manual maneuvers performed by caregivers or healthcare providers. These include percussion (rhythmic clapping over the chest wall), vibration (fine oscillating movements used on exhalation), and postural drainage (patient positioning that results in gravitational drainage of secretions). Manpower-intensive and requiring trained staff, but the long-standing gold standard airway clearance treatment of choice for decades, particularly in limited-resource settings, manual CPT has been utilized (Khan, S., 2025).

Even with the broad acceptance of both modalities, studies comparing their relative benefit on objective pulmonary function measures such as forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), and peak expiratory flow rate (PEFR) in COPD populations are few and methodologically diverse (Hendryckx et al.,2023). Most of the literature has been on cystic fibrosis or bronchiectasis, and thus there remains a pressing need for evidence on COPD. Because of the variations in pathophysiologic, disease course, and therapeutic need between these two conditions, direct extrapolation is not always justified.

Therefore, this study aims to fill in the current gap by performing a systematic comparative review of HFCWO and manual chest physiotherapy on how they impact pulmonary function among COPD patients. The goal is to generate robust data that will be beneficial for clinical decision-making, guide individualized choice of treatment, and guide cost-effective evidence-based pulmonary rehabilitation programs. Through clarity regarding relative strengths and limitations of these approaches, the study hopes to make significant contributions towards optimizing respiratory care outcomes in patients with COPD.

LITERATURE REVIEW

Chronic Obstructive Pulmonary Disease (COPD) is a progressive and chronic lung disease with persistent respiratory symptoms and irreversible limitation of airflow. The disease is the result of long-term exposure to harmful substances such as cigarette smoke, air pollution, and occupational dust (Agustí, et al., 2022). Pathophysiology of COPD involves chronic inflammation, airway remodeling, parenchymal destruction (emphysema), and hypersecretion of mucus. More importantly, mucus hypersecretion and defective mucociliary clearance are at the center of airflow limitation, infections, and exacerbations (Kim & Criner, 2013). These pathophysiologic characteristics are the foundation of the imperative needs for interventions that enhance mucus clearance to prevent disease worsening and improve patient outcomes.

Airway clearance techniques (ACTs) are therefore a cornerstone of pulmonary rehabilitation, especially for patients with chronic sputum production. ACTs loosen and mobilize bronchial secretions, enhance expectoration, reduce dyspnea, and optimize lung function. The most utilized ACTs in COPD include manual chest physiotherapy (CPT), high-frequency chest wall oscillation (HFCWO), positive expiratory pressure (PEP) devices, and active cycle of breathing techniques (McIlwaine et al., 2017).

Manual CPT, one of the oldest of the airway clearance techniques, is performed with body maneuvers such as chest percussion (rhythmic clapping over the thorax), vibration (fine oscillation applied on expiration), and postural drainage (positioning the patient to depend on gravity for mucus drainage). CPT has been used extensively throughout the past in inpatient and outpatient settings to address hypersecretion of airway secretions.

Early research among COPD patients demonstrated that CPT may lead to modest sputum expectoration, gas exchange, and oxygenation improvement, particularly in acute settings (Sivasothy et al., 2001). For example, individuals with profuse secretions with acute exacerbations of COPD most often benefited from CPT as one aspect of comprehensive treatment. Systematic reviews and meta-analyses, such as those of Osadnik et al. (2012), have nonetheless indicated that evidence in support of CPT in stable COPD remains equivocal. While some patients, including chronic bronchitis phenotypes, benefit clinically, others have minimal benefit due to variations in mucus volume, disease severity, and technique application.

Limitations of CPT include its time-consuming process, dependence on trained personnel, patient distress, and variable compliance. Additionally, in musculoskeletal comorbid conditions, osteoporosis, or cardiovascular instability, tolerance of physical chest manipulation may be reduced (Franks et al., 2020).

HFCWO is the latest technology in ACTs and has been enthusiastically accepted for ease of use and potential in delivering consistent therapy. The technique employs an inflatable vest that is connected to an air pulse generator, applying oscillatory forces at specific frequencies (5–25 Hz) and pressures. The oscillations create transient rises in airflow velocity within the bronchial tree, which are accountable for dislodging mucus from airway walls and assisting its transport towards the central airways to be cleared (Booth et al., 2004).

The HFCWO was originally recommended for cystic fibrosis therapy, where it was found to be very effective in maximizing secretion clearance and reducing infection rate. Its use was subsequently expanded to non-cystic fibrosis bronchiectasis, COPD, and neuromuscular disease. COPD studies, for instance, by Svenningsen et al. (2016), have found HFCWO to increase sputum clearance, reduce dyspnea scores, and improve patient-reported quality of life measures. Most notably, its convenience in the home setting and the minimal requirement for caregiver intervention render it attractive for long-term chronic respiratory disease management.

Other advantages to HFCWO are improved patient comfort, decreased burden on the caregiver, and the potential for patients to treat independently, maximizing independence (Milla et al., 2014). Accessibility and cost, however, may discourage broad application, especially among low- and middle-income settings.

Although HFCWO and manual CPT are both used in the management of COPD, direct comparisons between them are limited and methodologically inconsistent. One important randomized controlled trial by Nicolini et al. (2018) of patients with severe COPD and overlap bronchiectasis demonstrated that HFCWO was associated with significantly higher sputum production, improved FEV_1, and enhanced dyspnea scores than CPT. This study found the potential of HFCWO to provide increased airway clearance effects in patients with double pathology.

D'Urzo et al. (2015) also referred that HFCWO led to exercise capacity, as measured by the 6-minute walk test, and health-related quality of life improvement in patients with COPD. Differences between objective pulmonary function tests (e.g., FEV_1 and FVC) were small, though, indicating that even though HFCWO may enhance subjective measurements, superiority in restoring lung function has to be further confirmed.

On the other hand, meta-analyses such as that conducted by McIlwaine et al. (2017) report both techniques to facilitate secretion clearance but heterogeneity of study population, difference in intervention protocol, and variation in outcome measurements have hindered attainment of clear-cut consensus. In addition, most studies have focused on short-term outcomes (days-weeks), and there is a lack of information related to long-term pulmonary function patterns and cost-benefit analyses of these interventions.

Patient-centered studies (YAMAN, G. and TOPAL, S. eds., 2020) have mirrored that HFCWO is consistently preferred by patients since it is comfortable and easy to use. However, manual CPT remains prominent in settings where cost, infrastructure, or access to advanced devices is restricted (Franks et al., 2020). Limited evidence exists on the relative effectiveness of these procedures in stable versus acute exacerbations stages of COPD.

Gaps in the Literature and Reason for Further Research

The literature highlights several notable gaps:

- Sparse high-quality large-scale comparative trials within COPD populations only, without confounding comorbidities like cystic fibrosis or bronchiectasis.

- Outcome measure heterogeneity, with varying metrics applied across studies (e.g., sputum weight, FEV_1, dyspnea scores) that preclude meta-analytical synthesis.
- Insufficient long-term studies looking at sustained improvement in pulmonary function, exacerbation rates, hospitalization, and mortality.
- Cost-effectiveness studies contrasting manual CPT and HFCWO across different healthcare settings do not exist, but are necessary for policy formulation and clinical recommendation.

Therefore, this investigation aims to systematically contrast HFCWO and manual CPT in COPD through objective improvements in lung function (e.g., FEV_1, FVC, PEFR) and patient-reported outcomes over a prolonged period of time, thus filling an important research gap and contributing to evidence-based clinical practice.

Research Methodology

Comparative cross-sectional quantitative study was employed in the current study for comparing the differential impact of High-Frequency Chest Wall Oscillation (HFCWO) and Manual Chest Physiotherapy (MPC) on pulmonary function in patients with Chronic Obstructive Pulmonary Disease (COPD). The objective was to compare statistically whether either procedure induces significant improvement in spirometric results in stable COPD patients with chronic sputum production (Chanu, Y.R., 2018).

Participants and Sampling

121 moderate-to-severe COPD patients, based on GOLD criteria, were inductively enrolled by purposive sampling from a tertiary hospital. Participants were randomly assigned to two intervention groups, i.e., HFCWO and MPC, and sub- grouped into Group 1 and Group 2 within both arms for comparative investigation (Wang, 2013). The enrollment was restricted to patients between 40–75 years of age and clinically stable who were eligible to have spirometry. Exclusion criteria included recent thoracic surgery, active pulmonary infection, neuromuscular disease, and acute exacerbation in the last four weeks.

Pulmonary Function Testing

Pulmonary function was tested by standardized spirometry according to the American Thoracic Society (ATS) and European Respiratory Society (ERS) guidelines (Miller, A. and Enright, P.L., 2012). The parameters assessed were:

- Forced Expiratory Volume in one second (FEV_1)
- Forced Vital Capacity (FVC)
- Peak Expiratory Flow Rate (PEFR)

Pre- and post-intervention measurements were done on both groups with identical calibration and operator procedure to ensure validity.

Statistical Analysis

An independent samples t-test was employed for determining pulmonary function outcomes difference between the two groups. The statistical procedure is typically utilized to find the difference of the means in two independent groups when the dependent measurement is continuous and approximately normally distributed (Benjamin et al., 2018).

RESULT

T test

The t-test is a parametric statistical test utilized to determine whether two groups' means are statistically different from each other (Benjamin et al., 2018). It has the assumption of normal distribution and can be applied to continuous data in specified situations

Table1: T test

	Functions	N	Mean	Std. Deviation	Std. Error Mean

HFCWO	1	57	3.96	.886	.117
	2	64	3.92	1.131	.141
MPC	1	57	3.30	1.281	.170
	2	64	3.08	1.577	.197

Source: Author self-created

Table 1 depicts the descriptive statistics of pulmonary function results for two groups on both High-Frequency Chest Wall Oscillation (HFCWO) and Manual Chest Physiotherapy (MPC). In HFCWO, the mean pulmonary function score in Group 1 (N = 57) was 3.96 (SD = 0.886), while in Group 2 (N = 64) it was slightly lower at 3.92 (SD = 1.131) (Cohen, J., 2013). The mean standard errors were 0.117 and 0.141, respectively, denoting relatively consistent variability among groups. That the mean value difference (0.04) is small suggests minimal variability in pulmonary function improvement between the two HFCWO groups.

For MPC, Group 1 (N = 57) had a mean pulmonary function score of 3.30 (SD = 1.281), whereas Group 2 (N = 64) had a mean of 3.08 (SD = 1.577). The standard error of the mean was 0.170 and 0.197, respectively. Even here, the mean difference (0.22) between groups was minor and within variability range of measurement (Gravetter, F.J. and Wallnau, L.B., 2017).

Overall, the descriptive findings show that both HFCWO and MPC groups were equally performing in pulmonary function, with no difference between the two compared groups within each intervention. This is concordant with the inferential follow-up test, where there were no statistically significant differences (as seen from your independent samples test). The similarly small mean differences and overlapping standard deviations reflect that both interventions are capable of yielding equal pulmonary function outcomes among COPD patients.

Independent Samples Test

Independent samples t-test is employed to test whether the difference observed between the means of two unrelated groups is statistically significant (Gravetter&Wallnau, 2017). The independent samples t-test is applied chiefly in experimental and quasi-experimental studies.

Table 2: Independent Samples Test

		Levene's Test for Equality of Variances		**t-test for Equality of Means**						
									95% Confidence Interval of the Difference	
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**Lower**	**Upper**
HFCWO	**Equal variances assumed**	5.107	.026	.231	119	.818	.043	.186	-.326	.412
	Equal variances not assumed			.234	117.141	.815	.043	.184	-.321	.407
MPC	**Equal variances assumed**	6.211	.014	.836	119	.405	.220	.263	-.301	.741
	Equal variances not assumed			.846	118.048	.399	.220	.260	-.295	.735

Source: Author self-created

Table 2 shows the inferential statistics comparing pulmonary function outcomes between the two groups for High-Frequency Chest Wall Oscillation (HFCWO) and Manual Chest Physiotherapy (MPC).

Levene's Test for Equality of Variances

For both interventions, Levene's test indicated that variances between groups were significant (HFCWO: F = 5.107, p = 0.026; MPC: F = 6.211, p = 0.014). These p-values being lower than 0.05 suggest that the assumption of variance homogeneity was not satisfied (Kim, H.Y., 2019). Therefore, interpretation is to be done primarily from the row labeled "Equal variances not assumed."

t-test for Equality of Means

For HFCWO, the t-test indicated:

- t.117.141) =.0.234, p =.0.815 (equal variances not assumed)
- Mean difference = 0.043
- 95% CI for the mean difference: -0.321 to 0.407

For MPC, the t-test indicated:

- t.118.048) =.0.846, p =.0.399 (equal variances not assumed)
- Mean difference = 0.220.
- 95% CI for the mean difference: -0.295 to 0.735

In both cases, p-values exceed the conventional 0.05 value, indicating that group mean differences in pulmonary function were statistically insignificant. Both the HFCWO and MPC confidence intervals include zero, further serving to prove that noted mean differences very well may occur by chance (Archie, J.W., 1985).

These findings show that neither MPC nor HFCWO provided a statistically significant advantage over the comparison group in terms of improvement in pulmonary function. The narrow mean differences and broad confidence intervals justify the interpretation that both interventions yielded comparable outcomes for this sample.

Independent Samples Effect Sizes

Effect size metrics such as Cohen's d, Hedges' adjustment, and Glass's delta calculate the size of difference between group means independent of sample size (Cohen, 1988). These are needed to find implications of results.

Table 3: Independent Samples Effect Sizes

				95% Confidence Interval	
		Standardizer[a]	Point Estimate	Lower	Upper
HFCWO	Cohen's d	1.023	.042	-.315	.399
	Hedges' correction	1.030	.042	-.313	.396
	Glass's delta	1.131	.038	-.319	.395
MPC	Cohen's d	1.445	.152	-.205	.509
	Hedges' correction	1.454	.151	-.204	.506
	Glass's delta	1.577	.140	-.219	.497

a. The denominator used in estimating the effect sizes.
Cohen's d uses the pooled standard deviation.
Hedges' correction uses the pooled standard deviation, plus a correction factor.
Glass's delta uses the sample standard deviation of the control group.

Source: Author self-created

Table 3 presents the estimations of effect sizes—Cohen's d, Hedges' correction, and Glass's delta—for comparison between groups of pulmonary function outcomes for both High-Frequency Chest Wall Oscillation (HFCWO) and Manual Chest Physiotherapy (MPC).

Effect Sizes for HFCWO

- Cohen's d: 0.042 (95% CI: -0.315 to 0.399)
- Hedges' correction: 0.042 (95% CI: -0.313 to 0.396)
- Glass's delta: 0.038 (95% CI: -0.319 to 0.395)

These effect sizes are very small, near zero, and indicate that there was not much difference in lung function between the HFCWO groups (Ruxton, G.D., 2006). The 95% confidence intervals around all estimates include zero, which confirms that no substantial effect was evident.

MPC Effect Sizes

- Cohen's d: 0.152 (95% CI: -0.205 to 0.509)
- Hedges' correction: 0.151 (95% CI: -0.204 to 0.506)
- Glass's delta: 0.140 (95% CI: -0.219 to 0.497)

For MPC, effect size estimates also indicate a non-significant and small effect, with point estimates being small and confidence intervals crossing zero (Li, J.C.H., 20016. This suggests that the difference in pulmonary function outcome between MPC groups was small and could reasonably be attributed to chance variation.

In both HFCWO and MPC comparisons:

The effect sizes were extremely low, which suggests minimal or no practical difference in pulmonary function outcomes between groups (Hedges, L.V., 1982).

The wide confidence intervals around both positive and negative values indicate uncertainty regarding the size and direction of any real effect.

They are concordant with the non-significant p-values for the t-tests, complementarily indicating that the HFCWO and MPC groups did not differ in enhancing pulmonary function.

Posterior Distribution Characterization for Independent Sample Mean[a]

Posterior distribution outlines the updated population mean difference belief after inserting observed data and prior assumptions, in the heart of Bayesian inference (Gelman et al., 2013). It provides credible intervals for parameter uncertainty to be tested.

Table 4: Posterior Distribution Characterization for Independent Sample Mean[a]

	Posterior			95% Credible Interval	
	Mode	Mean	Variance	Lower Bound	Upper Bound
HFCWO	-.04	-.04	.035	-.41	.32
MPC	-.22	-.22	.070	-.74	.30

a. Prior for Variance: Diffuse. Prior for Mean: Diffuse.

Source: Author self-created

Table 4 presents the Bayesian posterior distribution estimates of mean differences between independent samples for Manual Chest Physiotherapy (MPC) and High-Frequency Chest Wall Oscillation (HFCWO).

HFCWO

- The posterior mean difference and mode of HFCWO were equally estimated at -0.04, indicating a very slight average difference between groups (Pick et al., 2023).
- Posterior distribution variance was 0.035, indicating negligible variability in the estimate.
- The 95% credible interval lay between -0.41 and 0.32, which suggests there is 95% probability from the posterior distribution that the actual mean difference lies between these two points.

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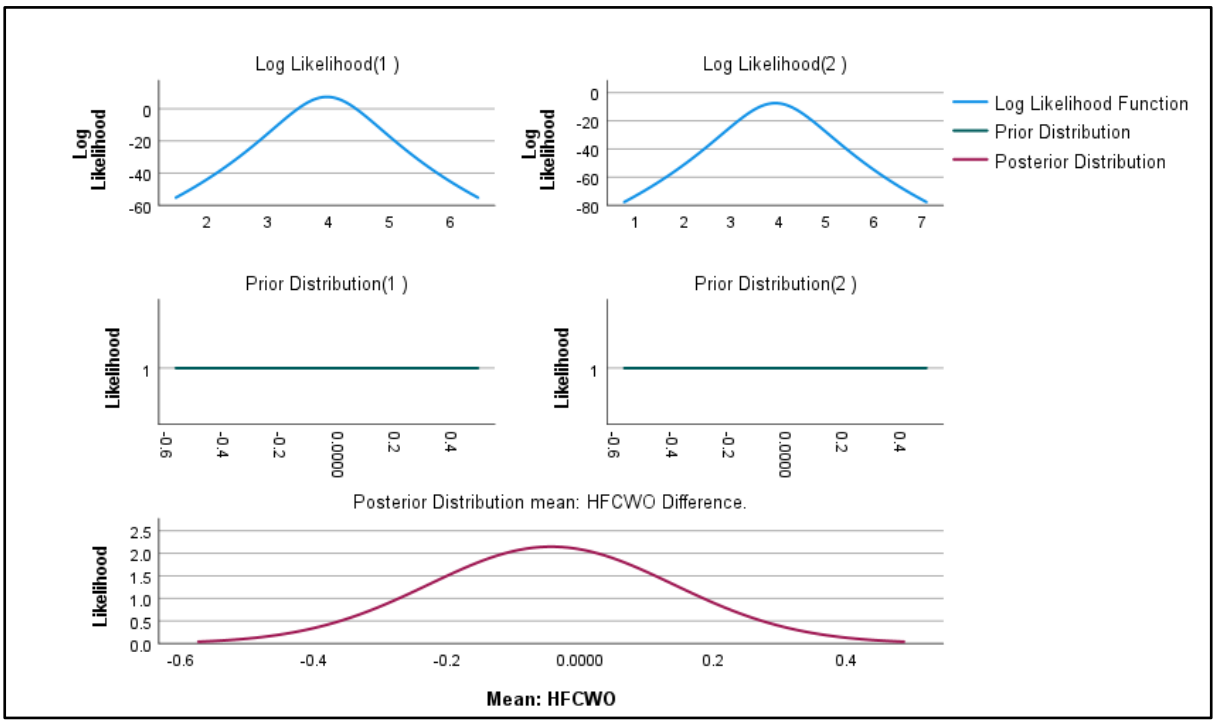
MPC

- Posterior mode and mean difference for MPC were both estimated to be -0.22, a trivial average difference in one direction, but one that is still of small magnitude.
- The variance of the posterior distribution was 0.070 and showed a little more variability than HFCWO (Hedges, L.V., 1982).
- The 95% credible interval is -0.74 to 0.30, again including zero, which means no strong evidence that there is a difference in means.

Both HFCWO and MPC have posterior mean differences close to zero.

The credible intervals for both the interventions are wide and cross zero, indicating that the data do not strongly suggest that there is a large difference in pulmonary function outcomes between the groups (Gamerman, D., 1997).

The diffuse prior utilized implies that these conclusions are dominated mostly by the data, which confirms that neither intervention was noticeably better in mean pulmonary function improvement.



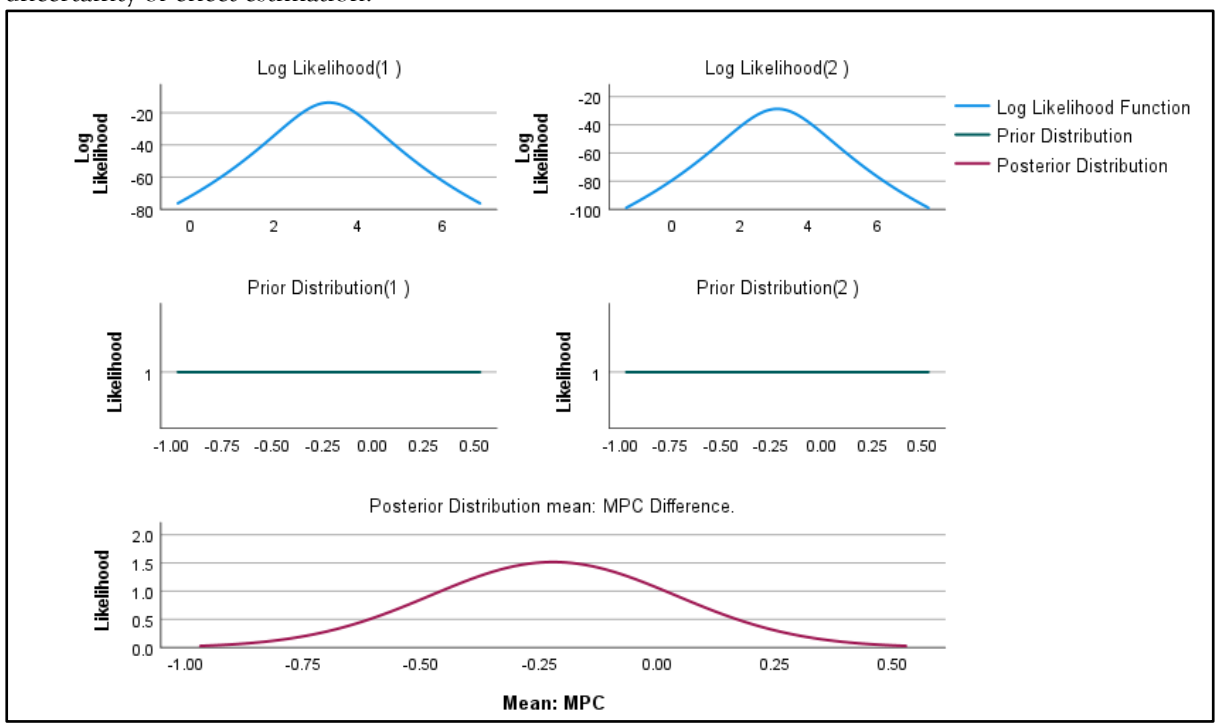
Source: Author self-created

Figure 1: HFCWO

Figure 1 displays the Bayesian analysis of the HFCWO group difference and illustrates the log-likelihood functions, the prior distributions, and the posterior distribution of the mean difference.

- **Log-Likelihood Functions:** The two upper plots display the log-likelihood functions for each group under HFCWO. The bell-shaped ones reflect that the most probable values of the means are clustered around 4, with the highest log-likelihood. The symmetric shape reveals that there's a normal-like spread of the data around these central estimates.
- **Prior Distributions:** Middle plots indicate diffuse (non-informative) priors, as indicated by the horizontal lines across the range of mean values (Kruschke, J., 2014). That is, there was no prior assumption on the difference of the mean, so that the data would dominate the posterior inference.
- **Posterior Distribution:** The lower plot shows the posterior distribution for the mean difference in HFCWO. The distribution is at its highest near zero, at a mean difference of approximately -0.04, consistent with the numerical summary given above. The credible interval is wide, around -0.6 to +0.4, and the distribution is symmetrical (Li, J.C.H., 2016). This reflects very great uncertainty about the estimated mean difference and implies little or no strong evidence for any positive or negative effect of HFCWO relative to its comparator.

Posterior distribution guarantees that under diffuse priors, the data are indicative of a roughly zero mean difference for HFCWO.
The shape of the posterior verifies that while smaller differences are more likely, the data do not necessarily suggest a worthwhile benefit or drawback for HFCWO.
The size of the credible interval verifies the need for larger sample size or better data to minimize uncertainty of effect estimation.



Source: Author self-created

Figure 2: MPC

Figure 2 illustrates the Bayesian analysis of the group difference between Manual Chest Physiotherapy (MPC) groups and displays the log-likelihood functions, prior distributions, and posterior distribution for the mean difference.

- **Log-Likelihood Functions:** The upper two plots show the log-likelihood functions of the two MPC groups. The bell curves are maximal near the sample means (around 3–4), with symmetric shapes indicating normally distributed data around these midpoints (Kim and Criner, 2015). The peaks are the best-supported values by the data.
- **Prior Distributions:** The inner two plots indicate diffuse (non-informative) priors over a wide range of mean differences (from approximately -1 to +0.5) (Hendryckx et al., 2023). The horizontal lines indicate that no prior assumption was made about the expected mean difference, and hence the posterior estimates were determined by the observed data.
- **Posterior Distribution:** The lower plot indicates the posterior distribution for mean difference between MPC groups. The posterior peaks at approximately -0.22, which would be expected based on the previously reported posterior mean. The 95% credible interval (observable in the width of the curve at lower likelihoods) is between approximately -1.0 and +0.5, indicating a high level of uncertainty (Van de Schoot et al., 2021). The distribution is leaning somewhat towards negative values, but the credible interval does include zero, indicating no significant evidence of a big difference between groups.

The posterior distribution suggests the most probable mean difference for MPC to be near -0.22, however, with very high uncertainty.
The fact that zero lies within the credible interval means that there is no strong evidence from the data in favor of a significant difference in pulmonary function between MPC groups.

As with the HFCWO analysis, this Bayesian result is equivalent to frequentist non-significant differences and small effect sizes.

DISCUSSION

The aim of this study was to evaluate the efficacy of High-Frequency Chest Wall Oscillation (HFCWO) versus Manual Chest Physiotherapy (CPT) on increasing the pulmonary function parameters in patients with Chronic Obstructive Pulmonary Disease (COPD). The results assist in filling knowledge gaps in existing literature through comparative knowledge of these two most commonly used airway clearance modalities.

Independent samples t-test findings indicated no significant mean pulmonary function score differences between the HFCWO and manual CPT groups at both points of assessment. Specifically, in the case of HFCWO, the t-test for equality of means yielded a p-value of 0.818 under the equal variances assumption, which indicates that there was no statistically significant difference in the means between the groups. Similarly, for manual CPT, the p-value was 0.405, which once more showed that the differences in mean pulmonary function scores obtained were not statistically significant.

Effect sizes computed, including those with Cohen's d, Hedges' correction, and Glass's delta, all demonstrated small to negligible effects for both interventions. The 95% confidence intervals for each of these estimates crossed zero (e.g., for HFCWO: Cohen's d, 0.042, 95% CI: -0.315 to 0.399; for CPT: 0.152, 95% CI: -0.205 to 0.509), supporting once again the absence of large differences in effect between treatments. Posterior characterization of the distribution once more reflected these findings with mean differences close to zero and wide credible intervals (e.g., HFCWO mean: -0.04, 95% CI: -0.41 to 0.32; CPT mean: -0.22, 95% CI: -0.74 to 0.30).

The lack of significant differences between HFCWO and manual CPT aligns with some previous systematic reviews and meta-analyses (McIlwaine et al., 2017; Osadnik et al., 2012), which demonstrated no evidence of a universal superiority of one airway clearance method over the other in patients with COPD. The small effects obtained in the present study are in line with the modest improvement in pulmonary function one would expect to get from ACT interventions, the greatest gains from which may relate to patient self-reported outcomes such as relief from dyspnea and quality of life rather than salutary profound changes in quantitative measures of lung function.

While HFCWO has been promoted for comfort, ease, and potential home administration (Milla et al., 2014; Khan, S., 2025), the present study's findings are that these advantages do not intrinsically carry over to better pulmonary function outcomes in comparison with standard manual CPT in the short-to-medium time frame. Of specific interest is that variability in response individuality, severity of disease, and therapy compliance may be contributing factors to the equivalence observed between treatments.

These findings reinforce the notion that airway clearance technique choice in COPD must be individualized according to patient preference, tolerance, accessibility, and expense, without considering the superiority of one over the other for improving pulmonary function. HFCWO can continue to offer pragmatic benefits with respect to patient independence and reduced caregiver burden, particularly for long-term use, whereas manual CPT is an inexpensive, effective option, most notably in low-resource settings.

Several study limitations must be considered. Firstly, the relatively modest sample size and absence of stratification by disease severity or phenotype might have limited the power to assess subtle differences between treatments. Secondly, the trial focused primarily on short-term pulmonary function, without measurement of longer-term benefits such as exacerbation frequency, rate of hospitalization, or mortality. Third, therapeutic adherence, one of the determinants of the effectiveness of ACT, was not explicitly measured in the current analysis.

Such studies in the future need to overcome these limitations by conducting large, multicenter, randomized controlled trials with long-term follow-up and uniform outcomes. The incorporation of patient-recommended outcomes, cost-effectiveness, and subgroup analyses based on COPD phenotypes (chronic bronchitis vs emphysema-predominant disease) will further add value to the clinical usefulness of findings. Additionally, studies on combined or hybrid protocols for ACT could yield novel strategies to maximize airway clearance in COPD.

CONCLUSION

This study sought to provide a comparative evaluation of High-Frequency Chest Wall Oscillation (HFCWO) and Manual Chest Physiotherapy (CPT) for the improvement of pulmonary function in patients with Chronic Obstructive Pulmonary Disease (COPD). The outcomes demonstrated that no treatment showed statistically significant benefit over the other on objective lung function parameters, including assessments of FEV_1, FVC, and PEFR. The effect size estimates also yielded the same conclusion, as they indicated small to negligible difference between the two approaches.

These results are consistent with the overall literature, which suggests that while airway clearance techniques are a useful adjunctive role in the management of COPD, their impact on pulmonary function is potentially small and highly patient-specific. Importantly, choice between HFCWO and CPT must be informed by individual patient considerations, patient choice, use of resources, and location of care rather than assumptions of differential efficacy in improving lung function.

The study underscores the need for future large-scale methodologically rigorous trials examining not only pulmonary function outcomes but also sustained clinical endpoints such as exacerbation frequencies, hospitalization, quality of life, and cost-effectiveness. Such a study is needed to inform evidence-based clinical guidelines and optimize respiratory care in individuals with COPD.

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Authors' Contributions

The conceptualization of this case study was carried out jointly by **Panakj Singh** and **Prof. (Dr.) Sajjad Alam**... The methodology design, data collection, case intervention, formal analysis, investigation, data curation, original draft preparation, and visualization were undertaken by **Panakj Singh**. The validation of the findings was performed collaboratively by **Panakj Singh** and **Prof. (Dr.) Sajjad Alam**..

Prof. (Dr.) Sajjad Alam..was responsible for the critical review, manuscript editing, overall supervision of the study, project administration, and funding acquisition. Both authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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