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Original Researcher Article

COMPARATIVE EFFECTIVENESS OF TELEREHABILITATION APPROACHES IN PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)

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Abstracts: **Introduction**: Telehealth innovations, including videoconferencing and video-based interventions, have emerged as promising alternatives to physical mode of pulmonary rehabilitation (PR). There is scarcity of literature on effect of telehealth PR on pulmonary functions in COPD patients. The present study tested the hypothesis that whether there is any significant difference between the effect of videoconferencing and video-based rehabilitation approaches on pulmonary function and functional outcomes in patients with COPD. **Materials and Methods:** A randomized clinical study was conducted among 118 patients with mild to severe COPD. Participants were allocated to a videoconferencing-based telerehabilitation group (VCF; n=59) or a video-based telerehabilitation group (VBT; n=59) and underwent a six-week PR program. Primary outcomes included spirometric parameters (FEV_1, FVC, FEV_1/FVC ratio, PEFR, inspiratory capacity, and tidal volume). Secondary outcomes included Modified Borg Scale, 6-minute walk test (6-MWT), COPD Assessment Test (CAT), and St. George's Respiratory Questionnaire (SGRQ). Pre- and post-intervention outcomes were analyzed using paired and independent t-tests. **Results**: Both groups showed significant improvements in modified Borg scale, FEV1, FVC, and FEV1/FVC ratios ($p<0.001$). Group-A (pre test 54.06±9.92, post test 60.81±8.160) demonstrated slightly better improvement in FEV1/FVC compared to Group-B (pre test 51.72±9.86, post test 55.47±9.797) ($p<0.05$), although changes in FEV1 ($p=0.95$) and FVC ($p=0.83$). Significant improvements in FEV_1, FEV_1/FVC ratio, dyspnoea, and CAT scores were observed in both groups ($p<0.001$). The VCF group demonstrated significantly greater improvements in FEV_1/FVC ratio, dyspnoea, exercise capacity (6-MWT), and CAT scores compared to the VBT group ($p<0.01$). No significant intergroup differences were found for FEV_1, FVC, PEFR, inspiratory capacity, tidal volume, or SGRQ scores.

Conclusion: Both videoconferencing-based and video-based telerehabilitation effectively improved pulmonary function and functional outcomes in COPD patients. Videoconferencing provided superior benefits in selected parameters, supporting tele-rehabilitation as an accessible and scalable alternative to conventional PR, particularly in resource-limited settings.

Keywords: Telemedicine, Chronic Obstructive, Forced Expiratory Volume, Pulmonary Function Tests, Vital Capacity, Pulmonary Rehabilitation

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a respiratory condition characterized by prolonged airflow restriction, progressive dyspnoea, and frequent exacerbations. [1,2]. The treatment of COPD depends on both non-pharmacological and pharmaceutical approaches. Non-pharmacological treatments, particularly pulmonary rehabilitation (PR), leads to improvement exercise endurance, dyspnoea, and functional ability [3,4]. Despite its efficacy, access to PR remains limited.

Barriers such as geographic distance, lack of trained personnel, high costs, transportation constraints, and adherence challenges particularly affect rural and resource-limited populations [5,6]. These obstacles underscore the need for alternative, accessible delivery models.In this context, telehealth innovations, including videoconferencing and video-based interventions, have emerged as promising alternatives to conventional PR. These models facilitate remote delivery of structured rehabilitation sessions, supervision, and patient engagement while minimizing geographic and logistical constraints [7].

Studies have concluded that telerehabilitation (Tele-R) significantly improves exercise capacity (6-minute walk distance [6MWD]), dyspnea (mMRC), and disease control (COPD Assessment Test [CAT]) compared to no rehabilitation; outcomes were comparable to center-based PR [8,9]. In comparison to traditional PR, videoconference-based PR also produced improvements in health-related quality of life and decreases in anxiety and sadness [10]. Videoconference PR produced comparable increases in patient understanding to in-person delivery, according to other observational studies [11]. Notably, existing studies primarily assess functional or patient-reported outcomes — for example, Modified Borg scale,6MWD, CAT, adherence, knowledge — and less frequently target pulmonary function parameters such as FEV_1, FVC, and FEV_1/FVC ratio. Spirometric indices, however, are fundamental markers of lung function, disease progression, and treatment response, and remain underexplored in the context of telehealth interventions [9].

This randomized clinical study aims to evaluate the effect of videoconferencing and video-based rehabilitation approaches on pulmonary function parameters (FEV_1, FVC, FEV_1/FVC ratio) in patients with COPD. By comparing these digital interventions with standard care, the study seeks to determine their capacity to yield meaningful improvements in objective lung function metrics alongside functional and patient-centered outcomes. This evidence may inform scalable, patient-centered, technology-enabled models for COPD management, with potential applicability in low-resource and rural healthcare settings.

MATERIALS AND METHODS

Study Design and sample size: - Randomized pre-test post-test study, parallel-group trial done at Pt. B.D. Sharma PGIMS, Rohtak, from August 2022 to August 2023. This study was approved by the institutional ethics committee of Pt. B.D.S. PGIMS, Rohtak vide no. (Ref. No. BREC/23/017). Written informed consent was obtained from all participants prior to enrolment. Based on previous study by Daniel et al. in which prevalence of COPD observed in India was 7.4 percentage as per fixed effect calculated ($p<0.0001$) [12], the minimum sample size with 5% level of significance and standard normal variant as 1.96, sample size of 118 patients with COPD was included in study.

Participants:

A total of 118 patients (71 males and 47 females), age 40-75 years, with mild to severe COPD according to GOLD [1] classification of COPD and those who were able to use smart phones and/or basic knowledge of operating a Smartphone were recruited from the Département of Pulmonary and Critical Care Medicine OPD, where preliminary evaluation and spirometry testing were performed. Patients with uncontrolled COPD, acute exacerbations requiring oxygen therapy, psychiatric illness or cognitive impairment were excluded from study. Eligible participants were randomized into two groups namely Videoconferencing-based Telerehabilitation group – VCF Group and Video-based Telerehabilitation group – VBT Group using random allocation sequence obtained from https://www.randomizer.org/.

Treatment Procedure

Baseline measurements (PRE) were recorded before initiation of the intervention and repeated after 6 weeks (POST). The primary outcomes included pulmonary function parameters (FEV_1, FVC, FEV_1/FVC ratio, Peak expiratory Flow Rate, Tidal Volume & Inspiratory capacity), 6-minute walk test, Modified Borgs Scale, COPD Assessment Test& St. George respiratory questionnaire. Both groups underwent a Pulmonary Telerehabilitation (PR) program for 6 weeks (12 sessions).

VCF Group:

Participants performed the PR program under the live supervision of a physiotherapist via videoconference. Exercises were conducted twice weekly for 6 weeks. Monitoring frequency was adjusted progressively: three times per week during weeks 1–2, twice per week during weeks 3–4, and once per week during weeks 5–6. Exercise protocol [14-15]followed for this group is given in Table1.

VBT Group

Participants were provided pre-recorded exercise videos covering the same protocol. They were instructed to perform exercises five times weekly for 6 weeks. Compliance was tracked using self-maintained exercise logs, with weekly monitoring calls. Monitoring frequency followed the same schedule as VCF Group: three times weekly during weeks 1–2, twice during weeks 3–4, and once during weeks 5–6 via phone calls. Exercise protocol [14-15] followed for this group is similar to that as for VCF Group and is given in Table1.

Outcome measures

Spirometric assessment of pulmonary function tests including Forced expiratory volume in 1st second of exhalation (FeV1), Forced vital capacity (FVC), FeV1/FVC ratio, Peak expiratory Flow Rate, (PEFR) Tidal Volume (TV) & Inspiratory capacity (IC), modified Borg's score (MBS), 6-Minute Walk Test (6MWT), COPD Assessment Test (CAT) and St. George Respiratory Questionnaire (SQRQ) ; were recorded before intervention and after completion of intervention for participants enrolled in both groups.

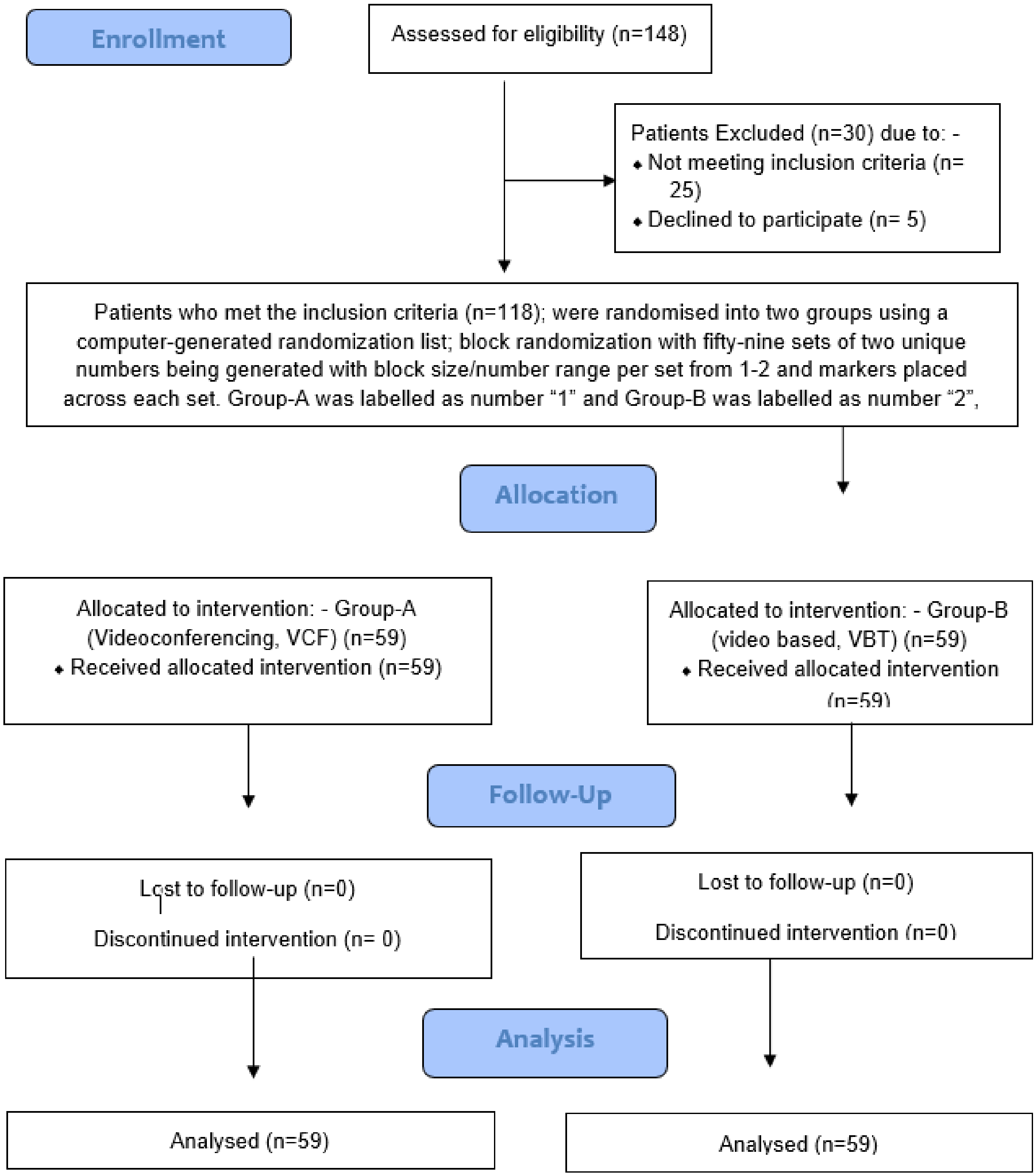

Figure 1: CONSORT (Consolidatedstandards of ReportingTrails) flow diagram of study participants from enrolment to analysis.

Statistical Analysis

SPSS software version 25.0 was used for statistical analysis. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean ± standard deviation (SD)($p< 0.05$). Comparison for within and between group differences for various outcome measures namely pulmonary functions (FeV1, FVC, FeV1/FVC ratio, PEFR, TV & IC), modified Borg Scale Score, 6-MWT, CAT and SGRQ at time-intervals: - baseline (PRE) and after six weeks of treatment (POST), for VCF Group and VBT Group was done using paired sample t-test and independent sample t-test ($p< 0.05$). Evaluation of treatment effect size was done by calculating between group- mean differences (delta mean values) and 95% C.I, for various outcome measures using an independent t-test. Bland-Altman plots were constructed to analyze between group- mean differences for various outcome measures.

RESULTS

There were no significant differences between mean values of age (p= .678), modified Borg scale score (p=.314), FVC(p=.249), FeV1 (p=.122), FeV1/FVC (p=.199), PEFR (p=.072), IC (p=.857), TV (p=.482), 6-MWT (p=.510), CAT score (p=.525), SGRQ (p=.531) and gender-wise distribution (p=0.617) of VCF Group and VBT Group study participants (table-2).

Within group analysis using paired t-test showed that there was highly significant increase (p<0.001) in outcome measures including FeV1, FeV_1/FVC, Modified Borg's Scale score and CAT score after 6 weeks of training within both groups. But FVC & PEFR in VCF Group was not statically significant (table 3). In VBT, 6-MWT was not statically significant. IC & TV were not significant in both groups. In comparison to baseline measures there was **higher percentage increase** in mean scores of pulmonary function tests, MBS scores and 6-MWT in participants of VCF group compared to those VBT group.

Between group comparison with independent sample t-test revealed a significant intergroup difference was observed in the mean change of Δ modified Borg's scale score, Δ FeV1/FVC, Δ CAT score and Δ 6-MWT, whereas no significant differences were detected in Δ FEV_1, Δ FVC, Δ PEFR, Δ IC, ΔTV, and Δ SGRQ between the two approaches. In contrast, the improvement in Δ FEV_1/FVC ratio was significantly greater in VCF Group, indicating that videoconferencing-based rehabilitation may confer a superior effect on this parameter compared to video-based rehabilitation (table 4).

DISCUSSION

The findings of this randomized controlled trial provide valuable insight into the effectiveness of VCF and VBT telerehabilitation approaches in improving pulmonary function parameters among patients with chronic obstructive pulmonary disease (COPD). Both modalities of pulmonary rehabilitation resulted in significant improvements, though the magnitude of changes varied across groups for specific parameters.

After six weeks of intervention, Group B (VBT) in this study showed a considerable improvement in forced vital capacity (FVC), while Group A (VCF) exhibited no change. This suggests that lung capacity may have been more significantly impacted by the repetitive and structured nature of video-based training. Modified Borg's scale was used to quantify dyspnoea and the results showed that both groups had a significant reduction in dyspnoea after 6 weeks of telerehabilitation. The reduction in dyspnoea was more apparent in Group A. There was a substantial disparity between Groups A and B. Priya et al.18 conducted an analogous study and found that telerehabilitation resulted in a significant decrease in Borg score.The study was further supported by Cox N S et al. [7] systematic review on telerehabilitation for chronic respiratory diseases. This analysis concludes that primary pulmonary rehabilitation or maintenance therapy administered by telerehabilitation for persons with chronic respiratory disease yields comparable outcomes to typical center-based pulmonary rehabilitation, with no safety concerns found. This shows that the videoconferencing method was more effective at minimizing dyspnoea. Tousignant M et al. [20]did a study on home telerehabilitation for older people with chronic obstructive pulmonary disease, and considerable improvement was noted in the Borg dyspnoea score.

Elkhateeb et al. found similar results, observing considerable increases in FVC following pulmonary rehabilitation, which they attributed to better respiratory muscle function and less airway blockage [16]. Programs for pulmonary rehabilitation that include deep breathing and inspiratory muscle exercises are believed to improve FVC by strengthening the respiratory muscles. On the other hand, Won et al. found no discernible increases in FVC after pulmonary rehabilitation, indicating that patient response varies based on modality and adherence [17]. There was no statistically significant difference between the two groups, but both showed notable increases in forced expiratory volume in one second (FEV_1). This aligns with the findings of Priya et al., who found that FEV_1 significantly improved in individuals with COPD following pulmonary rehabilitation [18]. These findings highlight the effectiveness of telerehabilitation in improving expiratory airflow and lowering airway obstruction in patients with COPD, regardless of whether treatment is provided using videoconferencing or video-based techniques. In both groups, the FEV_1/FVC ratio increased considerably; however, Group A (videoconferencing) showed an overall improvement than Group B. This result is consistent with that of Ghadimi et al., who showed that when COPD patients underwent rehabilitation, their FEV_1/FVC ratio significantly improved [19]. It's possible that the real-time monitoring, encouragement, and feedback given during videoconferencing improved exercise performance accuracy and adherence, which would account for Group A's better results. Overall, the findings show that both videoconferencing and video-based telerehabilitation techniques can improve pulmonary function in patients with COPD. However, the two methods offer different advantages: videoconferencing may improve the FEV_1/FVC ratio more effectively than video-based rehabilitation, which seems to be more effective at improving FVC. These results highlight the potential of remote pulmonary rehabilitation as a scalable substitute for traditional center-based programs, especially in environments with limited resources or accessibility.

Peak Expiratory Flow Rate (PEFR), Inspiratory Capacity (IC), and Tidal Volume (TV)—were also assessed to compare telerehabilitation approaches in COPD patients. Post-intervention, Group-B demonstrated significant improvement in PEFR after six weeks of video-based telerehabilitation, while Group-A showed only a non-significant change; however, no significant difference was seen between the groups overall. These findings imply that video-based telerehabilitation could offer greater benefit for PEFR, consistent with Cecily John S. H. and Alotaibi A. A. et al. (2013) [21] where breathing exercises improved pulmonary function in similar populations. Other studies Ma H. et al. (2022) [22] confirm improvements in PEFR after pulmonary rehabilitation, attributed to enhanced lung mechanics and respiratory muscle activation via deep breathing maneuvers. Nonetheless, some published research Kim H. T. et al. [23] indicate that not all interventions yield significant PEFR changes, highlighting variability across rehabilitation modalities.IC, results showed no significant improvements within or between groups, corroborating previous study by Varol Y et al. [24] & Moradians V et al. [25] that found limited effects of certain rehabilitation programs on inspiratory capacity. TV also remained unchanged between and within groups after the intervention, further aligning with published evidence by O. Georgiadou et al. [26]&Moradians V et al.[25]suggesting pulmonary rehabilitation often produces only modest effects on tidal volume in COPD patients. The reductions in the operational chest wall volumes during exercise after rehabilitation were mainly reflected in the abdominal and not in the ribcage compartment. After six weeks of telerehabilitation, Group-A showed significant improvement in the 6-Minute Walk Test (6-MWT), while Group-B did not, and the difference between groups was also significant. This suggests that videoconferencing-based rehabilitation more effectively improves aerobic capacity in COPD patients. The reason might may be low dropout rate and the high compliance with exercise training as supported by previous studies TSAI et al. [27] &P. Bernocchi et al. [28], while non-significant results may reflect differences in patient adherence or training intensity, supported by Hansen H et al. [29]

Both groups showed significant improvement in SGRQ scores after 6 weeks of telerehabilitation, with no significant difference between groups. Vasilopoulou et al. [12] reported that home-based telerehabilitation reduces COPD exacerbations and hospital visits, showing significant SGRQ improvement via videoconferencing. Similarly, Liu et al. [30] found significant SGRQ improvements after intervention. These benefits are attributed to high patient adherence, compliance with home exercises, empowerment, and effective self-management techniques.

Both groups showed a significant reduction in CAT scores after 6 weeks of telerehabilitation, with a significant difference between groups. These findings align with Zanaboni et al. [2]and Ghadimi et al. [31], supporting that both videoconferencing and video-based approaches effectively improve quality of life in COPD patients

STRENGTHS

The study has several strengths. First, it is one of the few randomized controlled trials conducted in the Indian population comparing two different telerehabilitation modalities in COPD patients. Second, randomization and standardized outcome measures such as Modified Borg scale score, spirometry, 6-MWT, CAT score and SGRQ strengthened the internal validity of the findings. Third, the study utilized accessible technologies such as smartphones, making the interventions scalable and feasible in resource-limited settings.

LIMITATIONS

Certain limitations should be acknowledged. The study duration was limited to six weeks, and long-term effects of the interventions on pulmonary function and quality of life were not assessed. Furthermore, the study did not explore patient satisfaction, cost-effectiveness, or psychosocial outcomes, which are important considerations for long-term implementation of telerehabilitation programs.

Clinical Implications

The outcomes of this study highlight the clinical utility of both videoconferencing and video-based approaches as effective, accessible, and scalable alternatives to traditional center-based pulmonary rehabilitation programs. Videoconferencing provides the added advantage of real-time interaction, monitoring, and feedback, which may improve patient adherence and exercise technique, particularly for those requiring greater supervision.

CONCLUSION

The pulmonary function parameters of patients with COPD were generally improved by both videoconferencing and video-based telerehabilitation; however, the effects of the video-based approach were more noticeable on FVC, whereas videoconferencing was more advantageous for increasing the FEV_1/FVC ratio. According to these results, both modalities can be useful substitutes for conventional in-person rehabilitation; the selection of a method should be based on patient preference, resource availability, and accessibility. More extensive research with extended follow-up is necessary to prove cost-effectiveness, sustainability, and wider therapeutic utility.

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DECLARATIONS

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Conflict of interest: None declare

S. No.	Mode of Exercise	Intensity	Frequency	Duration/Progression
1	Endurance training of lower limb: walking training on ground	Based on the dyspnoea score using Borg's scale	Twice a week via telerehabilitation	Initially 10–15 minutes, progressing to 30 minutes. Increase in exercise time and intensity as per Borg's scale. Includes warm-up and cool-down exercises with stretches (pectoralis, hamstring, shoulder).
2	Endurance training of upper limb: arm raises, arms together, star jacks	Based on Borg's scale	Twice a week via telerehabilitation	Initial duration of 10 minutes, progressively increased based on the patient's response to training. Exercises performed without weights.
3	Strength training of upper limb: shoulder press, biceps curl, wall press, pull-ups	Based on Borg's scale	Twice a week via telerehabilitation	Initial duration of 10 minutes, progressively increased based on the patient's response to training. Exercises performed with weights.

4	Strength training of lower limb: knee extension in sitting, sit-to-stand, step-up and step-down, heel raises	Based on Borg's scale	Twice a week via telerehabilitation	Initial duration of 10 minutes, progressively increased based on the patient's response to training. Exercises performed with weights.
5	Breathing training	Not applicable	Twice a week via telerehabilitation	Five repetitions per session, three sets, four times a day. Total duration of 15 minutes.
6	Home exercise	Not applicable	Three times a week	Exercises performed consistently for six weeks.

Table-1: Exercise Training Protocol

Characteristics	**VCF Group (n =59) Mean ±SD**	**VBT Group (n =59) Mean ±SD**	**p-value**	**t-value**
Age	57.07±10.03	57.81±9.41	.678	-.416
Male (81)	(41) 69.5	(40) 67.8	.079	3.085
Female (47)	(18) 30.5	(19) 32.5		
Modified Borg scale score	5.11±1.23	5.37±1.49	.314	-1.01
FeV_1 (in liters)	1.36±0.55	1.21±.48	.122	1.556
FVC (in liters)	2.44±0.73	2.29±.670	.249	-1.158
FeV_1/FVC (in %)	54.06±9.92	51.72±9.86	.199	1.29
PEFR	4.04±1.340	3.60±1.29	.072	1.819
IC	1.69±.5693	1.66±.57727	.857	.180
TV	1.45±.58	1.37±.6324	.482	.705
CAT score	22.59±3.948	22.10±4.412	.525	.638
6-MWT	308.17±63.78	316.83±77.64	.510	-.661
SGRQ	57.17±18.034	61.28±46.92	.531	-.629

Table-2: Baseline characteristics of study participants.

Variable	Group	PRE (mean ±SD)	POST (Mean ±SD)	Mean Difference	t-value	p-value
FeV1	VCF	1.36±.5501	1.46±.4799	0.10	2.477	.016**

	VBT	1.21±.4860	1.41±.4736	0.20	4.978	.000**
FVC	VCF	2.44±.7366	2.53±70.86	0.09	1.573	0.121 NS
	VBT	2.29±.6690	2.45±.6481	0.16	2.948	.005**
FeV1/FVC	VCF	54.06±9.92	60.81±8.160	6.7	10.129	.000**
	VBT	51.72±9.855	55.47±9.797	3.75	4.903	.000**
Modified Borg scale	VCF	5.11±1.23	2.38±.5877	2.73	14.019	.000**
	VBT	5.37±1.49	4.13±1.057	1.24	7.074	.000***
PEFR	VCF	4.04±1.340	4.25±1.266	-.20	-1.487	.142 NS
	VBT	3.60±1.29	4.00±1.413	-.40	-3.162	.002**
IC	VCF	1.69±.5693	1.83±.6149	-.14	-2.042	046 NS
	VBT	1.66±.57727	1.76 ±.5498	-.10	-1.550	127 NS
TV	VCF	1.45±.58	1.36±.5396	.09	1.065	.291 NS
	VBT	1.37±.6324	1.38±.5379	-.01	-.156	.877 NS
CAT score	VCF	22.59±3.948	14.39±3.434	8.20	19.899	.000**
	VBT	22.10±4.412	15.49±3.271	6.61	15.48	.000**
6-MWT	VCF	308.17±63.78	326.34±58.75	18.16	-7.615	.000**
	VBT	316.83±77.64	317.57±76.42	-.74	-.206	.837 NS
SGRQ	CVF	57.17±18.034	28.055±8.521	29.11	16.325	.000**
	VBT	61.28±46.92	29.32±10.90	31.96	5.307	.000**

**t- values and p values for within group comparisons
t- values and p values for between group comparisons

(**The mean difference is significant at <0.01 level)
(NS- non-significant)

Table 3:- Comparison of pulmonary function parameters within VCF Group and VBT Group

Variable	**VCF Group Mean ±SD**	**VBT Group Mean ±SD**	**Mean difference**	**t- value**	**p-value**
Δ FeV$_1$	.1019±.031	.1969±0.30	.095	1.666	.098NS
Δ FVC	.0937±0.45	.1612±0.42	0.83	.834	.406NS
Δ FeV$_1$/FVC	6.747±5.11	3.687±5.77	3.06	3.034	.003**
Δ Modified Borg' scale Score	2.728±1.495	1.237±1.34	1.491	5.700	.000***
Δ PEFR	.2044±1.055	.3981±.9670	.1937	1.039	.301 NS
Δ IC	.1418±.5333	.1032±.5116	.0385	.401	.689 NS
Δ TV	.0817±.5891	.0125±.6188	.0692	.847	399 NS
ΔCAT Score	8.203±3.166	6.610±3.280	1.593	2.684	.008**

Δ 6-MWT	18.16±18.32	.7432±27.66	17.424	4.034	000**
Δ SGRQ	29.11±13.70	31.96±46.26	.2.842	.453	.652 NS

(**The mean difference is significant at <0.01 level), (NS- non-significant)

Table 4--Comparison of pulmonary function parameters between VCF Group and VBT Group.

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