Evaluation of six-minute walk distance with and without pursed lip breathing in patients with chronic obstructive pulmonary disease

A paired single-session experimental study

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***Abstract*—Background: Chronic obstructive pulmonary disease limits exercise capacity because airways collapse early during expiration and air becomes trapped in the lungs. Pursed lip breathing is a simple technique that may reduce this problem during exertion. Objective: To compare the six-minute walk distance of patients with chronic obstructive pulmonary disease with and without pursed lip breathing. Methods: Fifty-eight diagnosed patients aged 45 to 75 years with mild breathlessness completed the six-minute walk test on two consecutive days, first with normal breathing and then with pursed lip breathing. Distances in meters were compared using the Wilcoxon signed-rank test. Results: The mean walk distance rose from 448.79 meters (standard deviation 59.48) without pursed lip breathing to 461.36 meters (standard deviation 58.81) with it, a mean gain of 12.57 meters. All 58 patients walked farther with pursed lip breathing (Wilcoxon Z of minus 6.70, p below 0.001). Conclusion: Pursed lip breathing produced a small but highly consistent improvement in walk distance. Because the test order was fixed, the result needs confirmation in randomized, counterbalanced trials.**

***Index Terms*—Chronic obstructive pulmonary disease, pursed lip breathing, six-minute walk test, functional capacity, physiotherapy.**

I. Introduction

Chronic obstructive pulmonary disease (COPD) is a group of conditions in which airflow is chronically obstructed, partly or completely, at any level from the trachea to the smallest airways, causing functional disability of the lungs [1]. COPD is a major global burden, with an estimated 300 million cases and 2.9 million deaths per year [2]. Deaths are projected to rise by 32% to 4.4 million per year by 2040, which would make COPD the fourth leading cause of death [2]. Smoking remains widespread, with 942 million men and 175 million women still smoking worldwide [3]. The World Health Organization estimates that ambient air pollution contributes 4.2 million deaths a year and household exposure to biomass fuels a further 3.8 million [4]. India and China together hold 33% of the world population but account for 66% of COPD mortality [5, 6], and global prevalence continues to be driven by both smoking and non-smoking risk factors [7].

COPD begins with damage to the airways and the small air sacs of the lungs [8]. The damaged airways become thickened and inflamed, which destroys the tissue where gas exchange occurs [9]. Airflow is reduced, less oxygen reaches the tissues, and removal of carbon dioxide becomes difficult, which leads to breathlessness during daily activities [9]. Common symptoms are cough, sputum production, exertional breathlessness and recurrent respiratory infection [10]. Prolonged exposure to harmful particles or gases is

the cause, cigarette smoking being the main one worldwide, followed by occupational and environmental exposures and alpha-1 antitrypsin deficiency [11].

Pursed lip breathing (PLB) reduces airway collapse, lowers respiratory rate and reduces dynamic hyperinflation. Studies indicate a greater tidal volume and a lower breathing frequency, and the raised expiratory airway pressure keeps the airways open and improves expiratory airflow [12]. The six-minute walk test (6MWT) is a self-paced, inexpensive test in which the patient walks as far as possible along a flat corridor for six minutes, and it is particularly useful for evaluating and monitoring patients with COPD [13, 14, 15]. The present study therefore examined whether PLB changes the six-minute walk distance (6MWD) in COPD patients. The null hypothesis was that there is no significant difference in 6MWD with and without PLB; the alternative hypothesis was that there is a significant difference.

II. REVIEW OF LITERATURE

Riaz et al. reported that diaphragmatic breathing combined with PLB outperformed PLB alone in reducing dyspnea and improving exercise capacity [16]. Kuanli and Qinlong found that PLB training improved lung function and quality of life in older adults with stable COPD [17]. A study assessed by the 6MWT found a significant benefit of PLB with diaphragmatic exercises on walk distance and quality of life compared with a control group [18], and Ariadie et al. similarly found a longer 6MWT distance when PLB was added to standard pulmonary rehabilitation [19]. Mohamed showed that PLB with a forward-leaning position improved physiological outcomes, dyspnea and anxiety [20]. A systematic review concluded that PLB reduces minute ventilation and respiratory rate during exercise, though it is unclear who responds best [21]. A randomized crossover study showed that PLB reduces dynamic hyperinflation and improves exercise tolerance and arterial oxygenation [22], and Bhatt et al. found that it acutely improves exercise capacity, particularly in patients with poorer baseline performance [23]. Earlier work showed sustained improvement in exertional dyspnea and physical function [24] and a more efficient breathing pattern with altered respiratory muscle recruitment [25].

III. MATERIALS AND METHODS

A. Study Design and Participants

This was an experimental study conducted at the Maharashtra Institute of Physiotherapy, Latur, over six months. Ethical clearance was obtained from the institutional ethics committee, and written informed consent was taken after the purpose and benefits of the study were explained in a language the participants understood. Participants were selected by simple random sampling, and the sample size of 58 was calculated with the formula $n = (Z\alpha/2 + Z\beta)^2 \times 2\sigma^2/d^2$.

B. Eligibility Criteria

Patients were included if they were 45 to 80 years old, of either sex, with a diagnosis of COPD, mild breathlessness, oxygen saturation above 94% and willingness to participate. Patients were excluded if they had other pulmonary diseases, musculoskeletal or neurological disorders, severe breathlessness or were ventilated.

C. Materials

The materials were a consent form, a data collection sheet, a pulse oximeter, a sphygmomanometer, a stethoscope, an inch tape for measuring distance, two cones, a stopwatch and a chair.

D. Procedure

Before each walk, blood pressure, pulse rate, respiratory rate, oxygen saturation and perceived exertion were recorded. Every participant performed the 6MWT on a marked walking track on two

consecutive days. On Day 1 the test was done with normal breathing (without PLB). On Day 2 the test was done with PLB. Participants were taught PLB first: inhale slowly through the nose, as if smelling a flower, then exhale slowly through gently pursed lips, as if blowing out a candle, for 8 to 10 repetitions. They kept using PLB while walking, slowed down if breathless, and could stop to rest while continuing PLB. Rest and safety measures were provided whenever required. The distance walked in six minutes was recorded in meters.

E. Outcome and Statistical Analysis

The outcome measure was the 6MWD in meters. Data were recorded on a structured proforma and entered in a spreadsheet. Quantitative data are expressed as mean and standard deviation (SD). Normality was tested with the Shapiro-Wilk test, and the paired comparison used the Wilcoxon signed-rank test with a 0.05 level of significance. A paired t-test was run as a sensitivity check. Because the same patients were tested in both conditions, the two conditions are called “without PLB” and “with PLB” rather than separate groups.

IV. RESULTS

A. Participant Characteristics

Fifty-eight patients with COPD completed both walks. Their ages ranged from 45 to 75 years (mean 59.6, SD 9.3), and 33 (56.9%) were men and 25 (43.1%) women. The largest age groups were 45 to 55 years and 56 to 65 years with 21 patients each (36.2%), followed by 66 to 75 years with 16 patients (27.6%) (Table I).

TABLE I. AGE AND GENDER DISTRIBUTION (N = 58)

Variable	Category	Frequency	Percentage
Age, years	45–55	21	36.2
	56–65	21	36.2
	66–75	16	27.6
Gender	Male	33	56.9
	Female	25	43.1

B. Six-Minute Walk Distance

The mean 6MWD was 448.79 m (SD 59.48) without PLB and 461.36 m (SD 58.81) with PLB, a mean gain of 12.57 m (SD of the gain 3.78; 95% confidence interval 11.57 to 13.56 m) (Table II). The median gain was 11.5 m and individual gains ranged from 5 to 25 m.

TABLE II. SIX-MINUTE WALK DISTANCE (M), N = 58

Condition	Mean	SD	Median	Range
Without PLB	448.79	59.48	460	288–540
With PLB	461.36	58.81	475	300–555
Difference	12.57	3.78	11.5	5–25

C. Comparison With and Without PLB

Shapiro-Wilk testing gave $p = 0.064$ for distances without PLB and $p = 0.094$ with PLB, but the paired differences were clearly non-normal ($p < 0.001$). A paired non-parametric test was therefore used.

The Wilcoxon signed-rank test showed 0 negative ranks, 58 positive ranks and no tied pairs ($Z = -6.70$, $p < 0.001$), so the distance with PLB was higher in every participant (Table III). The paired t-test agreed ($t = 25.3$, $df = 57$, $p < 0.001$). The null hypothesis was rejected and the alternative hypothesis accepted.

TABLE III. WILCOXON SIGNED-RANK TEST (N = 58)

Statistic	Value
Negative ranks	0
Positive ranks	58
Ties	0
Z value	−6.70
p value	< 0.001
Inference	Significant

V. DISCUSSION

PLB produced a statistically significant increase in 6MWD in COPD patients. The mean distance rose from 448.79 to 461.36 m, and all 58 patients improved, an unusually uniform response that is the most notable feature of the result.

The finding has a clear physiological basis. In COPD, inflammation, remodeling of the small airways and loss of elastic recoil make the airways narrow and collapse early during expiration [8], excess mucus adds to the obstruction [9], and expiratory flow limitation grows with disease severity and appears as exertional breathlessness [10, 11]. During exercise a rising respiratory rate shortens expiratory time, which worsens air trapping and dynamic hyperinflation and forces patients to slow or stop. Exhaling against pursed lips creates back-pressure that splints the airways open for longer [25], slows the respiratory rate and prolongs expiration, allowing fuller emptying of the lungs [24]. This plausibly lets patients sustain walking for longer, as shown previously [23, 22].

The direction of the result agrees with earlier work. PLB with or without diaphragmatic breathing improved exercise capacity and dyspnea [16], a structured PLB programme improved lung function and quality of life [17], and added to pulmonary rehabilitation it increased 6MWT distance [19, 18]. PLB with a forward-leaning position also lowered dyspnea and anxiety, suggesting a psychological contribution [20]. A systematic review confirmed reduced minute ventilation and respiratory rate with PLB during exercise but noted that responders are poorly defined [21]; our sample was not stratified by disease stage or smoking history.

The mean gain of 12.57 m is modest and should be read cautiously, and it is smaller than the change generally regarded as clinically meaningful for this test. The 6MWT is a well-validated, low-cost field test of functional capacity [13, 15, 14]. What the result shows convincingly is a consistent, reproducible response rather than a large clinical effect from one session. Because PLB needs no equipment, costs nothing and can be taught in minutes, even a small per-session benefit is worth pursuing, and supervised training over several weeks [17] might turn this immediate advantage into a larger and more durable gain.

VI. LIMITATIONS

- *Fixed test order.* Every participant walked without PLB on Day 1 and with PLB on Day 2, without randomization or counterbalancing, so a practice or learning effect on the second walk cannot be separated from the effect of PLB.

- *Short-term effect only.* PLB was assessed on two consecutive days; persistence and carry-over to daily life are unknown.
- *No blinding and no separate control group.* Patients and assessor knew the condition, so expectation, motivation and encouragement may have influenced the distance.

VII. CONCLUSION

PLB significantly improved the six-minute walk distance of COPD patients compared with normal breathing. Because it is simple, inexpensive, non-invasive and easily taught, it can reasonably be added to physiotherapy management and pulmonary rehabilitation and encouraged during walking and other exertional activities. The average gain was modest and the design had limitations, so the finding should be confirmed in better controlled trials before firm clinical recommendations are made.

VIII. FUTURE SCOPE

- A randomized, counterbalanced crossover trial with adequate washout, or a parallel-group trial with a blinded assessor, would remove order effect and bias.
- Stratifying patients by disease stage, age, sex and body mass index could identify who responds best.
- Future studies could examine daily activities, other exercise tests, exacerbations and admissions, and home-based or tele-rehabilitation delivery.

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