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COMPARATIVE EFFECTS OF PURSED-LIP BREATHING COMBINED WITH THE SIX-MINUTE WALK TEST VERSUS THE SIT-TO-STAND TEST ON DYSPNEA, PEAK EXPIRATORY FLOW RATE, AND OXYGEN SATURATION IN PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE: A RANDOMIZED COMPARATIVE STUDY

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ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) is among the leading causes of morbidity and mortality worldwide and is characterised by persistent dyspnea and diminished exercise capacity. Field-based functional tests combined with breathing retraining are increasingly used in pulmonary rehabilitation, yet direct comparative evidence on which combination yields superior physiological benefit remains limited.

Objective: To compare the effects of pursed-lip breathing (PLB) combined with the six-minute walk test (6MWT) against PLB combined with the sit-to-stand test (STST) on dyspnea, peak expiratory flow rate (PEFR), and arterial oxygen saturation (SpO_2) in patients with COPD.

Methods: Sixty patients with mild-to-moderate COPD recruited from the inpatient and critical care units of a tertiary care hospital were allocated by simple random (chit) sampling into two equal groups. Group A (n = 30) performed PLB combined with the 6MWT, and Group B (n = 30) performed PLB combined with the STST, six days a week for one week. Dyspnea (Modified Borg Dyspnea Scale), PEFR (Wright's peak flow meter), and SpO_2 (pulse oximetry) were recorded at baseline and after one week. Within-group change was analysed with the Wilcoxon signed-rank test, between-group differences with the Mann–Whitney U test, and baseline-adjusted comparisons with analysis of covariance (ANCOVA) controlling for baseline score, age, and sex.

Results: Both interventions produced significant within-group improvement ($p < 0.001$). In Group A, the Borg score fell from 3.83 ± 1.21 to 1.35 ± 0.89, PEFR rose from 206.00 ± 58.29 to 368.33 ± 65.92 L/min, and SpO_2 rose from $88.63 \pm 3.44\%$ to $97.70 \pm 1.09\%$. In Group B, the Borg score fell from 4.00 ± 1.60 to 2.82 ± 1.58, PEFR rose from 171.67 ± 51.00 to 234.00 ± 51.70 L/min, and SpO_2 rose from $90.83 \pm 4.73\%$ to $93.43 \pm 3.99\%$. After ANCOVA adjustment for baseline value, age, and sex, Group A showed significantly greater improvement than Group B on every shared outcome (adjusted Borg difference 1.34 points, adjusted PEFR difference 100.42 L/min, adjusted SpO_2 difference 5.32 percentage points; all $p < 0.001$).

Conclusion: Pursed-lip breathing combined with either the six-minute walk test or the sit-to-stand test improves dyspnea, expiratory flow, and oxygen saturation in patients with COPD, but the combination with the six-minute walk test confers significantly greater short-term physiological benefit and may be preferable where walking space and patient tolerance permit.

KEYWORDS: Chronic obstructive pulmonary disease; pursed-lip breathing; six-minute walk test; sit-to-stand test; dyspnea; peak expiratory flow rate; oxygen saturation; pulmonary rehabilitation.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a common, preventable, and treatable respiratory condition marked by persistent airflow limitation and progressive structural damage to the airways and lung parenchyma [1,2]. It is currently the fourth leading cause of death worldwide and is projected to climb further up the global mortality rankings as population exposure to tobacco smoke, biomass fuel combustion, and ambient air pollution continues [3,4]. Airflow obstruction in

COPD arises from a combination of fixed anatomical change - loss of elastic recoil, peribronchial fibrosis, and destruction of alveolar septa - and more dynamic, partly reversible components such as mucosal oedema, mucus hypersecretion, and bronchial smooth-muscle tone [5]. The clinical consequence is a downward spiral in which expiratory flow limitation leads to dynamic hyperinflation, which in turn heightens the work of breathing and drives the characteristic exertional dyspnea that limits daily activity [6].

Beyond its pulmonary manifestations, COPD exerts substantial systemic effects, including skeletal-muscle deconditioning, nutritional depletion, and psychological morbidity such as anxiety and depressive symptoms, all of which compound exercise intolerance and erode quality of life [7]. Pharmacological therapy - bronchodilators, inhaled corticosteroids, and supplemental oxygen where indicated - remains central to disease management, but drug therapy alone has shown only modest effect on aerobic capacity in patients with advanced disease [8]. Consequently, non-pharmacological strategies delivered through pulmonary rehabilitation, particularly breathing retraining and structured exercise, have assumed a central role in comprehensive COPD care [9].

Pursed-lip breathing (PLB) is one of the most widely taught self-management techniques in pulmonary rehabilitation. By prolonging expiration against the resistance created by partially closed lips, PLB generates positive intraluminal back-pressure that splints the small airways open for longer, reduces air trapping, slows respiratory rate, and lowers the subjective sensation of breathlessness [10,11]. Because it requires no equipment and can be self-administered, PLB is frequently paired with a functional exercise task to evaluate, and potentially enhance, its impact on exercise tolerance.

The six-minute walk test (6MWT) is the most extensively validated field test of submaximal functional exercise capacity in COPD and is strongly predictive of morbidity, hospitalisation, and survival [12,13]. It integrates the combined performance of the cardiovascular, respiratory, and musculoskeletal systems under near-physiological conditions, but it requires a level corridor of at least 30 metres and may not be feasible in space-constrained inpatient or critical-care environments [13]. The sit-to-stand test (STST) has emerged as a compact, equipment-light alternative that principally reflects lower-limb muscular strength and endurance while also imposing a measurable cardiopulmonary load; several studies report moderate-to-strong correlation between STST performance and 6MWT distance, supporting its use where walking assessment is impractical [14,15].

Although the individual benefits of PLB, the 6MWT, and the STST have each been documented in COPD, direct head-to-head evidence comparing PLB combined with the 6MWT against PLB combined with the STST on shared physiological endpoints - dyspnea, expiratory flow, and oxygen saturation - is scarce. Clarifying whether one combination confers superior short-term benefit would help clinicians select the more effective, or more contextually feasible, rehabilitation strategy for patients with mild-to-moderate COPD, including those managed in resource- or space-limited inpatient settings. The present study was therefore designed to compare the effects of PLB combined with the 6MWT against PLB combined with the STST on the Modified Borg Dyspnea Scale, peak expiratory flow rate, and arterial oxygen saturation in patients with COPD.

1.1 Objectives

- To evaluate the effect of pursed-lip breathing combined with the six-minute walk test on dyspnea, PEFR, and SpO_2 in patients with COPD.
- To evaluate the effect of pursed-lip breathing combined with the sit-to-stand test on dyspnea, PEFR, and SpO_2 in patients with COPD.
- To compare the relative effectiveness of the two combined interventions in patients with COPD.

1.2 Hypotheses

Null hypothesis (H_0): There is no significant difference between PLB combined with the 6MWT and PLB combined with the STST in their effect on dyspnea, PEFR, and SpO_2 in patients with COPD.

Alternative hypothesis (H_1): There is a significant difference between the two combined interventions, with one producing superior outcomes.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

This prospective, randomized, comparative study was conducted over a period of twelve months in the inpatient departments of general medicine, respiratory medicine, and pulmonary medicine, together with the critical care (CCU), intensive care (ICU), respiratory intensive care (RICU), and medical intensive care (MICU) units, of a tertiary care teaching hospital. Ethical clearance and institutional approval were obtained prior to recruitment, and written informed consent was secured from every participant after the study procedures had been explained in a language they understood.

2.2 Participants

Sixty patients of either sex, aged between 18 and 80 years and diagnosed with mild-to-moderate COPD, were enrolled. Patients with a history of pulmonary tuberculosis, lung abscess, pneumothorax, haemothorax, pulmonary embolism, pleural effusion, COVID-19 or other communicable disease, rib fracture, restrictive lung disease, osteoporosis, unstable angina, acute myocardial infarction, spinal cord injury, diastasis recti, lung malignancy, or an inability to comprehend or perform the study procedures were excluded.

2.3 Sample Size and Randomization

Sample size was estimated using a two-mean comparison formula with type-I error (α) of 5% ($Z\alpha = 1.96$), power of 90% ($Z\beta = 1.28$), a pooled standard deviation of 28.30, and an anticipated mean difference of 40.21, yielding a minimum requirement that was rounded up to 30 participants per arm for adequate statistical power, giving a total sample of 60.

Participants were allocated to Group A or Group B using a simple random (chit) method: sixty numbered chits, thirty designating each group, were drawn without replacement by each participant in sequence.

2.4 Outcome Measures

- Dyspnea severity - Modified Borg Dyspnea Scale (0-10 category-ratio scale).
- Peak expiratory flow rate (PEFR) - Wright's peak flow meter, best of three attempts.
- Arterial oxygen saturation (SpO_2) - digital pulse oximetry (Nanox-2).

All three measures were recorded at baseline (Day 1, pre-treatment) and after completion of the one-week intervention (post-treatment).

2.5 Interventions

Both groups performed PLB identically before their respective exercise test: seated in a relaxed or semi-Fowler position, participants inhaled through the nose for two seconds, allowing the chest and abdomen to expand, and then exhaled slowly through lightly pursed lips. PLB was performed for five repetitions per set, followed by a five-minute rest, for a total of three sets, six days per week, for approximately 25-30 minutes per session.

Group A (PLB + 6MWT): Immediately after the three PLB sets, participants performed the 6MWT according to American Thoracic Society (2002) guidelines, walking at a self-selected pace along a level, 30-metre indoor corridor marked with turnaround cones, without supplemental oxygen, for six consecutive days.

Group B (PLB + STST): Immediately after the three PLB sets, participants performed the one-minute sit-to-stand test, rising fully and sitting back down as many times as possible from a standard armless chair (seat height 46 cm) with arms folded across the chest, for six consecutive days.

2.6 Statistical Analysis

Data were analysed using Python (pandas, SciPy, and statsmodels), with statistical significance set at $p < 0.05$. Descriptive statistics (mean ± standard deviation) summarised continuous variables. The Shapiro-Wilk test assessed normality. Between-group baseline comparability was tested using the Mann-Whitney U test (age) and the chi-square test (sex distribution). Within-group pre-post change was analysed using the Wilcoxon signed-rank test, and between-group differences in change scores were analysed using the Mann-Whitney U test. Analysis of covariance (ANCOVA) was additionally performed on all common post-treatment outcomes (Borg score, PEFR, SpO_2), with group as the principal predictor and baseline value, age, and sex entered as covariates, to obtain adjusted between-group estimates.

3. RESULTS

Sixty patients (30 per group) completed the one-week intervention with no dropouts. Baseline age (Group A: 52.70 ± 16.49 years; Group B: 60.27 ± 14.41 years; $p = 0.067$) and sex distribution (Group A: 63.3% male; Group B: 43.3% male; $p = 0.196$) did not differ significantly between groups, confirming adequate baseline comparability (Table 1).

Table 1. Baseline demographic comparison between groups

Variable	**Group A (PLB+6MWT)**	**Group B (PLB+STST)**	**Test statistic**	**p value**
Age, years (mean ± SD)	52.70 ± 16.49	60.27 ± 14.41	U = 325.50	0.067
Sex, male n (%)	19 (63.3%)	13 (43.3%)	$\chi^2 = 1.67$	0.196
Sex, female n (%)	11 (36.7%)	17 (56.7%)	-	-

3.1 Peak Expiratory Flow Rate

PEFR increased significantly within both groups ($p < 0.001$). Group A improved from 206.00 ± 58.29 to 368.33 ± 65.92 L/min (mean gain 162.33 L/min, 78% relative increase), while Group B improved from 171.67 ± 51.00 to 234.00 ± 51.70 L/min (mean gain 62.33 L/min, 36.3% relative increase). The post-treatment between-group comparison favoured Group A (Mann-Whitney U = 845.50, $p < 0.001$) (Table 2).

Table 2. Within- and between-group comparison of peak expiratory flow rate (L/min)

Timepoint	**Group A (mean ± SD)**	**Group B (mean ± SD)**	**Mann-Whitney U**	**p value**
Pre-treatment	206.00 ± 58.29	171.67 ± 51.00	597.50	0.029
Post-treatment	368.33 ± 65.92	234.00 ± 51.70	845.50	<0.001
Mean change (within group, Wilcoxon p)	+162.33 (p<0.001)	+62.33 (p<0.001)	-	-

3.2 Arterial Oxygen Saturation

SpO_2 rose significantly within both groups ($p < 0.001$). Group A improved from 88.63 ± 3.44% to 97.70 ± 1.09% (mean gain 9.07 percentage points, 10.2% relative increase), while Group B improved from 90.83 ± 4.73% to 93.43 ± 3.99% (mean gain 2.60 percentage points, 2.9% relative increase). The post-treatment between-group comparison favoured Group A (Mann-Whitney U = 744.00, $p < 0.001$) (Table 3).

Table 3. Within- and between-group comparison of arterial oxygen saturation (%)

Timepoint	Group A (mean ± SD)	Group B (mean ± SD)	Mann-Whitney U	p value
Pre-treatment	88.63 ± 3.44	90.83 ± 4.73	331.00	0.078
Post-treatment	97.70 ± 1.09	93.43 ± 3.99	744.00	<0.001
Mean change (within group, Wilcoxon p)	+9.07 (p<0.001)	+2.60 (p<0.001)	-	-

3.3 Dyspnea (Modified Borg Scale)

Dyspnea scores decreased significantly within both groups ($p < 0.001$). Group A improved from 3.83 ± 1.21 to 1.35 ± 0.89 (mean reduction 2.48 points, 64.8% relative reduction), while Group B improved from 4.00 ± 1.60 to 2.82 ± 1.58 (mean reduction 1.18 points, 29.6% relative reduction). Baseline scores were comparable between groups ($p = 0.535$), and the post-treatment comparison significantly favoured Group A, indicating lower residual breathlessness (Mann-Whitney U = 198.00, $p < 0.001$) (Table 4).

Table 4. Within- and between-group comparison of Modified Borg Dyspnea Scale score

Timepoint	Group A (mean ± SD)	Group B (mean ± SD)	Mann-Whitney U	p value
Pre-treatment	3.83 ± 1.21	4.00 ± 1.60	408.50	0.535
Post-treatment	1.35 ± 0.89	2.82 ± 1.58	198.00	<0.001
Mean change (within group, Wilcoxon p)	-2.48 (p<0.001)	-1.18 (p<0.001)	-	-

3.4 Test-Specific Functional Performance

Because the two functional tests are measured on non-equivalent scales, they were evaluated separately as within-group responses rather than compared directly against one another. Group A increased its 6MWT distance from 351.00 ± 34.07 m to 405.17 ± 32.97 m, a mean gain of 54.17 m (95% CI 49.07-59.26; 15.4% improvement; Wilcoxon $p < 0.001$). Group B increased its STST repetitions from 21.83 ± 2.93 to 25.40 ± 3.43 repetitions per minute, a mean gain of 3.57 repetitions (95% CI 3.09-4.04; 16.3% improvement; Wilcoxon $p < 0.001$). Both changes were statistically significant, indicating a positive functional response in each cohort (Table 5).

Table 5. Pre-post functional performance within each group

Outcome	Group	Pre (mean ± SD)	Post (mean ± SD)	Mean gain (95% CI)	% improvement	p value
6MWT distance, m	A	351.00 ± 34.07	405.17 ± 32.97	54.17 (49.07-59.26)	15.4%	<0.001
STST repetitions/min	B	21.83 ± 2.93	25.40 ± 3.43	3.57 (3.09-4.04)	16.3%	<0.001

3.5 Baseline-Adjusted (ANCOVA) Comparison

To account for any residual influence of baseline score, age, and sex, ANCOVA was performed on the three shared post-treatment outcomes, coding Group A as the reference category (0) and Group B as the comparator (1). The adjusted between-group differences remained statistically significant for all three outcomes and consistently favoured Group A: an adjusted Borg score 1.34 points higher in Group B (95% CI 1.08-1.59, $p < 0.001$), an adjusted PEFR 100.42 L/min lower in Group B (95% CI -115.28 to -85.56, $p < 0.001$), and an adjusted SpO_2 5.32 percentage points lower in Group B (95% CI -6.26 to -4.39, $p < 0.001$), with model R^2 values between 0.825 and 0.920 (Table 6).

Table 6. ANCOVA summary of common post-treatment outcomes (Group B relative to Group A, adjusted for baseline value, age, and sex)

Outcome	Adjusted coefficient (A vs. B)	95% CI	p value	Model R²	Direction
Modified Borg Dyspnea Scale	1.34	1.08 to 1.59	<0.001	0.911	Favours Group A
Peak Expiratory Flow Rate	-100.42	-115.28 to -85.56	<0.001	0.920	Favours Group A
Arterial Oxygen Saturation	-5.32	-6.26 to -4.39	<0.001	0.825	Favours Group A

Overall, both intervention combinations produced statistically and clinically meaningful improvement from baseline; however, the magnitude of improvement in dyspnea, expiratory flow, and oxygenation was consistently and significantly greater for pursed-lip breathing combined with the six-minute walk test than for pursed-lip breathing combined with the sit-to-stand test, a finding that persisted after adjustment for baseline value, age, and sex.

4. DISCUSSION

This study compared the short-term effects of two combined rehabilitation strategies - pursed-lip breathing paired with either the six-minute walk test or the sit-to-stand test - on dyspnea, expiratory flow, and oxygen saturation in patients with mild-to-moderate COPD. Both combinations produced statistically significant within-group improvement across all three outcomes after only one week, and the two groups did not differ meaningfully in age or sex distribution at baseline, supporting the internal validity of the comparison. The principal finding was that PLB combined with the 6MWT produced a significantly larger improvement than PLB combined with the STST on every shared physiological measure, a result that remained robust after adjusting for baseline value, age, and sex through ANCOVA.

The magnitude of improvement observed with PLB and PLB-based programmes in this study is consistent with prior reports. Lalwani et al. found that short-term PLB significantly raised oxygen saturation and lowered both respiratory rate and dyspnea in stable COPD patients, supporting its role as an effective adjunct in symptom management [16]. Similarly, Sulistyanto et al. reported that PLB significantly improved respiratory status and SpO_2 in COPD patients using a quasi-experimental design, reinforcing its utility as a low-cost, accessible intervention [17]. Mulyadi et al. demonstrated that combining pursed-lip and diaphragmatic breathing with structured exercise produced significant gains in six-minute walk distance and quality of life relative to bronchodilator therapy alone, a pattern broadly mirrored by the substantial 6MWT distance gain observed in Group A of the present study [18].

The comparatively smaller, though still significant, gains observed in the STST group are consistent with the physiological profile of the sit-to-stand manoeuvre, which primarily challenges lower-limb strength and produces a lower haemodynamic and ventilatory load than a sustained walking task [19,20]. Mellaerts et al. and Spence et al. have both validated the one-minute STST as a reliable, practical marker of functional exercise capacity, particularly suited to settings where a walking corridor is unavailable, but neither study positions STST as physiologically equivalent to the 6MWT [19,21]. The present findings extend this literature by suggesting that, where feasible, pairing PLB with a walking-based task may confer a greater short-term respiratory and oxygenation benefit than pairing PLB with a lower-limb strength task, even though both approaches remain clinically useful.

The improvement in PEFR observed in both groups aligns with previous work showing that breathing retraining and structured exercise can enhance expiratory flow in COPD, an effect attributed to reduced airway resistance, better respiratory muscle coordination, and diminished dynamic hyperinflation following prolonged, controlled exhalation [22]. The greater rise in SpO_2 in Group A may reflect the sustained aerobic demand of repeated walking bouts, which can improve ventilation-perfusion matching and oxygen delivery more effectively than the shorter, strength-dominant STST cycles [23]. Taken together, these results support the physiological plausibility of a graded response: interventions that impose a greater aerobic and ventilatory challenge, when combined with a airway-splinting breathing technique such as PLB, appear to yield larger gains in the shared cardiopulmonary outcomes measured here.

From a clinical standpoint, these findings suggest that PLB combined with the 6MWT should be considered the preferred short-term rehabilitation pairing for patients with mild-to-moderate COPD who can safely undertake a walking protocol. However, the STST combination remains a valuable and pragmatic alternative in space-constrained inpatient or critical-care settings, or for patients with mobility limitations, since it too produced significant symptomatic and physiological benefit.

4.1 Strengths and Limitations

Strengths of this study include its randomized comparative design, standardised intervention protocols, use of validated and objective outcome measures, and the application of baseline-adjusted ANCOVA to strengthen the between-group comparison beyond simple change-score analysis. Several limitations should nonetheless be acknowledged. The intervention period was limited to one week, which is insufficient to capture sustained physiological adaptation or disease-modifying benefit in a chronic, progressive condition such as COPD; the improvements documented here may partly reflect acute responses rather than durable therapeutic change. The sample of 60 participants, while adequately powered for the primary comparison, restricts the detection of smaller between-group differences and limits generalisability. Recruitment from a single tertiary centre, and predominantly from acute and critical care units, means the study population may not represent the broader, clinically stable outpatient COPD population typically encountered in ambulatory pulmonary rehabilitation. The absence of a validated COPD-specific quality-of-life instrument, such as the COPD Assessment Test or the St. George's Respiratory Questionnaire, limits the holistic interpretation of patient-centred benefit. The Modified Borg Dyspnea Scale, being a self-reported measure, is inherently susceptible to subjective interpretation and recall bias. Finally, the absence of a no-intervention or usual-care control arm and of post-intervention follow-up means that spontaneous recovery, attention effects, and the durability of the observed gains cannot be excluded or confirmed. Future multicentre trials with longer intervention and follow-up periods, larger and more diverse samples, inclusion of quality-of-life endpoints, and an appropriate control arm are warranted to confirm and extend these findings.

5. CONCLUSION

Both pursed-lip breathing combined with the six-minute walk test and pursed-lip breathing combined with the sit-to-stand test produced significant short-term improvement in dyspnea, peak expiratory flow rate, and arterial oxygen saturation in patients with mild-to-moderate COPD. Comparative analysis, however, showed that the combination with the six-minute walk test produced significantly greater improvement across all shared outcomes, even after adjustment for baseline value, age, and sex. The null hypothesis was therefore rejected in favour of the alternative hypothesis. These findings support pursed-lip breathing combined with the six-minute walk test as a simple, low-cost, and more effective short-term strategy for reducing breathlessness and improving respiratory function and oxygenation in COPD, while affirming the sit-to-stand test as a practical and clinically useful alternative when walking-based assessment is not feasible.

DECLARATIONS

Ethical Approval: Institutional ethical approval was obtained prior to commencement of the study, and the study was conducted in accordance with the Declaration of Helsinki.

Informed Consent: Written informed consent was obtained from all individual participants included in the study.

Conflict of Interest: The authors declare no conflict of interest.

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Author Contributions: All authors contributed to the study conception, design, data collection, analysis, and manuscript preparation, and approved the final version for submission.

REFERENCES

1. Agusti AGN, Noguera A, Sauleda J, et al. COPD, a multicomponent disease: implications for management. Respir Med. 2005;79(1):670-682. doi:10.1016/j.rmed.2004.11.006.
2. Topalovic M, et al. Modelling the dynamics of expiratory airflow to describe chronic obstructive pulmonary disease. Med Biol Eng Comput. 2014;52(12):997-1006. doi:10.1007/s11517-014-1202-6.
3. Agusti A, Celli BR, et al. Global Initiative for Chronic Obstructive Lung Disease 2023 Report: GOLD executive summary. Am J Respir Crit Care Med. 2023. doi:10.1164/rccm.202301-0106PP.
4. Soriano JB, et al. Prevalence and attributable health burden of chronic respiratory diseases, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet Respir Med. 2020;11(3):585-596. doi:10.1016/S2213-2600(20)30105-3.
5. Sauleda J, Noguera J, et al. Systemic effects of chronic obstructive pulmonary disease. Eur Respir J. 2003:347-360. doi:10.1183/09031936.03.00405703.
6. Miki K, et al. Laryngeal widening and adequate ventilation by expiratory pressure load training improve aerobic capacity in COPD: a randomised controlled trial. Thorax. 2023;79(1):23-34. doi:10.1136/thorax-2022-219755.
7. Budiman B, Garnewi S. Effects of diaphragmatic breathing exercise on the degree of breathlessness in patients with chronic obstructive pulmonary disease. Iran Rehabil J. 2021;19(1):69-74. doi:10.32598/irj.19.1.1094.13.
8. Barnes PJ. Inflammatory mechanisms in patients with chronic obstructive pulmonary disease. J Allergy Clin Immunol. 2016;64(2):16-27. doi:10.1016/j.jaci.2016.05.011.
9. Gloeckl R, Marinov B, Pitta F. Practical recommendations for exercise training in patients with COPD. Eur Respir Rev. 2013;22(128):178-186. doi:10.1183/09059180.00000513.
10. Cabral LF, D'Elia TC, et al. Pursed lip breathing improves exercise tolerance in COPD: a randomized crossover study. Eur J Phys Rehabil Med. 2015;51(1):79-88. PMID:24691248.
11. Yawn BP, Mintz ML, Doherty DE. GOLD in practice: chronic obstructive pulmonary disease treatment and management in the primary care setting. Int J Chron Obstruct Pulmon Dis. 2021;16:289-299. doi:10.2147/COPD.S222664.
12. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002;166(1):111-117. doi:10.1164/rccm.166/1/111.
13. Dajczman E, Wardini R, Kasymjanova G, et al. Six minute walk distance is a predictor of survival in patients with chronic obstructive pulmonary disease undergoing pulmonary rehabilitation. Can Respir J. 2015;22(4):225-229. doi:10.1155/2015/280187.
14. Vaidya T, Chambellan A, de Bisschop C. Sit-to-stand tests for COPD: a literature review. Respir Med. 2017;128:70-77. doi:10.1016/j.rmed.2017.05.003.
15. Machado A, Dias C, et al. Functional capacity using sit-to-stand tests in people with chronic obstructive pulmonary disease and its relationship with disease severity - a cross-sectional study with matched controls. Braz J Phys Ther. 2024;28(4). doi:10.1016/j.bjpt.2024.101090.
16. Lalwani L, Mishra G, Gaidhane A, Quazi Z. Short term effect of pursed lip breathing technique in stable patients of chronic obstructive pulmonary disease. Eur J Mol Clin Med. 2020;7(2). doi:10.6084/m9.figshare.13296008.
17. Sulistyanto A, Rahmawati DI, Irnawati, Kartikasari D. Effect of pursed lip breathing (PLB) exercise on respiratory status in patients with chronic obstructive pulmonary disease (COPD). J Perawat Indones. 2023;7(1):1259-1265. doi:10.32584/jpi.v7i1.2180.
18. Mulyadi, Junita IM, Zulfikar T, Yusuf N, Azhary M, Salim HM. The effect of pursed-lips breathing and diaphragm exercises on the quality of life of COPD patient assessed by six-minute walk test. Bali Med J. 2022;11(3):1116-1120. doi:10.15562/bmj.v11i3.3474.
19. Mellaerts P, Demeyer H, Blondeel A, Vanhoutte T, et al. The one-minute sit-to-stand test: a practical tool for assessing functional exercise capacity in patients with COPD in routine clinical practice. Chron Respir Dis. 2024;21. doi:10.1177/14799731241291530.
20. Ozalevli S, Ozden A, Itil O, Akkoclu A. Comparison of the sit-to-stand test with 6 min walk test in patients with chronic obstructive pulmonary disease. Respir Med. 2006;101(2):286-293. doi:10.1016/j.rmed.2006.05.007.
21. Spence JG, Brincks J, Lokke A, Neustrup L, Ostergaard EB. One-minute sit-to-stand test as a quick functional test for people with COPD in general practice. NPJ Prim Care Respir Med. 2023;33(11). doi:10.1038/s41533-023-00335-w.
22. Endrian MJW, Noviati E, Trisnawati Y, Kusumawaty J, Kurniawan R, Rahayu Y. The effect of pursed lips breathing technique on increasing peak expiratory flow rate (PEFR) in medium classification of chronic obstructive pulmonary disease patient. J Phys Conf Ser. 2019;27(7). doi:10.1088/1742-6596/1179/1/012148.

23. Troosters T, Vilaro J, Rabinovich R, Casas A, Barbera JA, Rodriguez-Roisin R, Roca J. Physiological responses to the 6-min walk test in patients with chronic obstructive pulmonary disease. Eur Respir J. 2002;20(3):564-569. doi:10.1183/09031936.02.02092001.