

RESEARCH ARTICLE

The historical perspective on pursed lip breathing exercises and its role in pulmonary rehabilitation programs

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Abstract

Background: Pursed lip breathing (PLB) is an important aspect of respiratory exercise training utilized by patients with chronic obstructive pulmonary disease (COPD) to alleviate symptoms of dyspnea. This modality became a part of the recommended treatment during pulmonary rehabilitation and was endorsed by ACCP/AACVPR (American College of Chest Physicians/ American Association of Cardiovascular and Pulmonary Rehabilitation) in 1997. ¹ Theoretically, PLB promotes maximum exhalation by creating back-pressure inside the airways and thereby improving patency. These changes in respiratory mechanics counteract the pathophysiology leading to emphysema and optimize pulmonary function, thus decreasing dyspnea symptoms associated with dynamic hyperinflation. While there is no overwhelming evidence to support the efficacy of PLB, clinicians still encourage their patients to use PLB techniques during their pulmonary rehabilitation program.

Methods: A total of 26 research articles met criteria for inclusion in this review.

The purpose of this review is to better understand the historical perspectives and evidence surrounding the use of PLB.

Discussion: Most evidence suggested that PLB could be an effective self-care management that optimizes pulmonary function. The knowledge gained from this review may be used to explore implementation strategies utilizing pursed lip breathing exercises for developing a home-based pulmonary rehabilitation program in order to optimize pulmonary function and quality of life in COPD patients.

Keywords: PLB; COPD or chronic obstructive pulmonary disease; pulmonary rehabilitation program

Introduction

Twelve million Americans have been diagnosed with chronic obstructive pulmonary disease or COPD.² The mortality from COPD has increased over the period between 1969 and 2013, while mortality caused by other important and common diseases has decreased over that same time-span.³ COPD is a disease characterized by several subtypes or phenotypes including chronic bronchitis, asthma, and emphysema. In addition to common respiratory issues such as dyspnea, chronic bronchitis, and bronchospasm, there are non-pulmonary ramifications of the disease, including psychiatric conditions, which occur with a prevalence of up to 50% in those with COPD.⁴ Combining these factors, the hospitalization rates and re-admission rates continue to be a significant source of disease burden in this population.⁵ About 75% of COPD cases are related to cigarette smoking and the rest are caused by environment exposure, asthma, and genetic disorders. Public health strategies are focused on tobacco-use prevention and cessation, air purity, and early management of asthma.⁶ The Centers for Disease Control and Prevention has established objectives to reduce mortality, morbidity, hospitalization readmission rates, and improve quality of life among individuals with COPD.⁶ Empowering patients and encouraging active participation have shown positive effects on chronic disease management in a home setting. Literature review over the last 50 years of research on patients with COPD demonstrated that, over time, therapeutic trends have shifted towards a dual emphasis on medical management along with self-care management.⁷ Therefore self-care management skills may be incorporated formally into medical care management through the use of pulmonary rehabilitation programs that are implemented in the home setting. For this review, only the use of pursed lip breathing

(PLB) exercises and its impact on chronic disease progression will be explored.

Review of Literature

The origin of the terminology and its impact on COPD pathogenesis

Pursed Lip Breathing (PLB) has been observed in subjects with COPD and emphysema as a patient-initiated method to curb dyspnea, and it was first advocated as a breathing exercise for this purpose by Saenge in 1910 and Hofbauer in 1925.⁸ When these patients were asked to open their mouths to breathe out instead of using PLB, they immediately developed severe dyspnea and suffocation. The term PLB was utilized as the patients had lips almost completely sealed while they were exhaling. However, the term pursed lip or puckered lip breathing was not well characterized, and the techniques taught to patients varied depending on the clinician. PLB was defined as a self-induced type of positive-pressure breath.⁹ One definition given by Wikipedia, is that PLB is a breathing technique that consists of exhaling through tightly pressed lip (pursed lips) and inhaling through nose with mouth closed.¹⁰ The “tightly” is the word that can be subjective and open to interpretation. The online free medical dictionary gives a very similar definition as Wikipedia; however, it removed “tightly” from the “tightly pursed lip”.¹¹ Regardless of “tightly pursed lip” vs. “pressed lip”, the purpose of this breathing is to slow down the air flow during the exhalation to build up back pressure in the airway to avoid a sudden drop in intrapulmonary pressure resulting in alveolar and airway collapse. In emphysema patients, the primary pathophysiologic mechanism is the destruction of the elastic tissue that causes eventual fusion of the alveoli into bullae. These bullae can be easily expanded but have limited recoil capacity due to the lack of elastic structure, thus leading to

prolongation of exhalation, air trapping, and development of the physical finding of a barrel chest. Normally, the elasticity will generate pressure as the alveoli are stretched during inhalation and allow for air to flow out of the lung during exhalation. However, in the case of COPD, the lack of elastic recoil will cause collapse of the air-

ways, thereby causing air to be trapped in the alveoli (i.e., bullae) and eventually CO₂ retention.¹² Theoretically, PLB will form a “high pressure (higher than the atmosphere)” in the airway by either “pressing the lip” or forming tightly pursed lip to prevent the sudden collapsing of the alveoli (bullae).

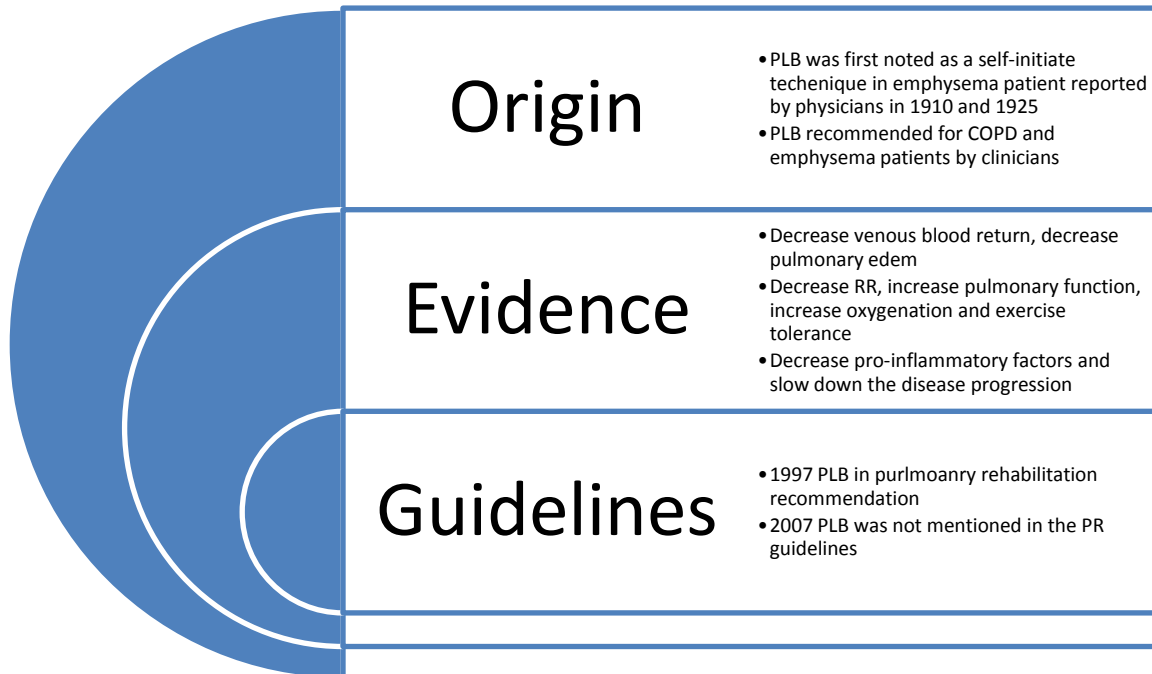


Figure 1: PLB: An evidence based practice?

PLB: An evidence based practice for being in the guidelines

Scientists have conducted decades of research to explore PLB and its health benefits. PLB was removed from 1997 guidelines due to its inconsistency scientific evidence (Figure 1). The purpose of this review is to identify the plausible causes of these inconsistent findings and provide possible suggestions for supporting or not supporting pursed lip breath in COPD disease management. PubMed is used for the literature review on PLB and its effectiveness on COPD disease management. Using key searching terms “pursed lip breath” or “pursed lips” yield

135 articles. Adding the filter of “COPD or chronic obstructive pulmonary disease, or emphysema” by using the PubMed Advanced Search Builder, only 66 articles remained with the time span from 1960 to 2018. There were only 26 research articles and sample sizes varied from 6 to 69 (see attachment A).

It has been reported that there are naturally pursed lip breathers, who can self-initiate the PLB to prevent dyspnea, due to their anatomic nasopharynx and distinctive anatomy.¹³ PLB is a technique that allows air to leave the airway more slowly, which has been taught to COPD patients as a means to

prevent alveolar collapse.¹⁴ In addition, the early studies indicated that PLB has beneficial effects on patient's dyspnea by decreasing venous blood return, improving pulmonary edema, improving ventilation over time,¹⁵ and decreasing PaCO₂ due to prolonged exhalation.¹⁶ Other studies indicated that PLB can improve hyperinflation, residual volume,¹⁷ and increase physical activity tolerance.¹⁸ Recent studies indicated that overdistended alveoli are associated with elevated pro-inflammatory mediators, which are associated with the destruction of the lung parenchyma.¹⁹ Freeman et al reported that IL-10, IL-15, and other pro-inflammatory cytokines are elevated in the serum along with CRP.²⁰ Another study compared COPD patients who walked less than 350 meters to those who were able to walk more than 350 meters and found that those with decreased walk distances had elevated levels of the pro-inflammatory cytokine IL-8 and lower physical function scores. Moreover, those with higher walk distances had surfactant protein B levels that were associated with a higher physical functionality.²¹ There was also an improvement in bronchial end expiratory pressure in patients using PLB.¹⁶ Nield et al studied 40 COPD subjects and reported that 14 of those in the PLB group had significant improvement in dyspnea scores at week 12 compared to those in the EMT (expiratory muscle training) and control groups. In this study, the PLB group also showed significant improvement in physical function.²² In a randomized crossover study in 40 stable COPD patients aged 40 to 75 with FEV₁ < 60%, Cabral et al reported that PLB decreases expiratory peak flow and respiratory rate, improving exercise tolerance, and arterial oxygenation.²³

However, other research demonstrates that the effectiveness of PLB in pulmonary rehabilitation is not conclusive, and some studies did not provide consistent findings that PLB improves pulmonary function.²⁴⁻²⁶ In a ran-

domized cross-over study, de Aaraujo and associates reported that PLB decreases hyperinflation, however, it did not improve results on six minute walk test and functional capacity.²⁷ The potential reasons for these disparate findings may be related to the non-standardized manner by which clinicians provided teaching on performing pursed lip breathing exercises. Dr. Tiep, the editor of *Journal of Cardiopulmonary Rehabilitation and Prevention*, stated in the editorial that the "major difficulty presented by many PLB studies is that there is no standard instruction on PLB albeit the PLB has demonstrated its effectiveness on improving exercise tolerance in a selected small group of COPD patients"²³. This likely reflects the practice guideline change that has occurred with pulmonary rehabilitation and the use of PLB in COPD disease management.

PLB in Pulmonary Rehabilitation Program

Pulmonary rehabilitation has been defined as a multidisciplinary, tailored program designed to optimize physical function, social status, and autonomy. Pulmonary rehabilitation has focused on not only exercise training, which is the cornerstone of most programs, but also supportive care, education, smoking cessation, and nutritional support.²⁸ PLB is a technique that is taught in most pulmonary rehabilitation centers. The American College of Chest Physicians (ACCP) and the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) jointly published their evidence-based clinical practice guidelines in 2007. In this report, pulmonary rehabilitation did not improve the survival rates or decrease the mortality rates.¹ However, the report suggested that patients developed increased independence, a greater level of physical function—including the ability to perform activities of daily living, and had better

quality of life; all of these parameters represent outcomes that should be targeted in future pulmonary rehabilitation studies.¹ Interestingly, and in contrast to the 1999 pulmonary rehabilitation report, PLB exercises were not mentioned in the 2007 report.²⁹ The experts acknowledge the potential benefit of pursed lips breathing in the reduction of dyspnea, but did not clearly endorse the practice in the 2007 guidelines. Furthermore, poor utilization of pulmonary rehab services could pose additional challenges to the widespread use of PLB in COPD patients. Fischer et al reported that on average there were anywhere from 20-70% non-completion rates. Moreover, of the 217 patients referred to pulmonary rehabilitation, 23% did not adhere to their rehabilitation plan.³⁰ Hayton et al reported that of 711 patients prescribed pulmonary rehab, only 69% attended the session and 29% were non-adherent.³¹ Other studies report that about 50% of referrals to pulmonary rehabilitation do not use the service at all.³² Even among those who complete a pulmonary rehabilitation program, only 9 of 13 participants continue to use the PLB in their self-management.¹⁸

Discussion

Most evidence suggests that PLB may be promoted as an effective self-care management tool in individuals with COPD to optimize pulmonary function (see attachment 1). The potential beneficial effects of pursed lips breathing include: decrease in hyperinflation, amelioration of the pro-inflammatory state of the lung, reduction in venous return, lessen in pulmonary edema, improvement in pulmonary function, better exercise tolerance, and enhanced quality of life.

Difficulty with executing effective and standardized PLB instruction, inconsistencies among research studies regarding the effectiveness of PLB reported in the literature,

and poor utilization of pulmonary rehabilitation programs may potentially overshadow the important role of PLB in COPD management, especially in the home setting. Since not all participants continue to use PLB after completing pulmonary rehabilitation, it is of paramount importance that we not only develop a standardized protocol for providing instruction on the use of PLB, but also creating an effective monitoring and coaching tool to support the use of PLB exercises in these symptomatic COPD patients. Future studies should focus on developing an easy to use pulmonary rehabilitation program that incorporates the use of pursed lip breathing exercises or even exploiting a resistive device that may be able to coach patients on how to effectively perform PLB exercises in any outpatient settings or at home.

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Appendix

Research articles reviewed on pursed lip breathing

#	Year	Title / Journal	Sample size	Key research variables studied	Pursed lips and settings
1	1960	"Pursed lip" spirometry in the assessment of an anti-spasmodic as treatment for chronic bronchitis and emphysema. <i>Guys Hosp Rep</i> , 109, 130-138	25	Vital capacity and FEV1 has improved after BD (bronchial dilator)	Yes. PLB used in chronic bronchitis and emphysema patients
2	1966	The efficacy of pursed-lips breathing in patients with chronic obstructive pulmonary disease. <i>Am Rev Respir Dis</i> , 93(1)	21	All male patients, VC, lung volumes, mechanics of breathing, and PaCO ₂ and PaO ₂ .	Yes. Pursed lips group has decrease in respiration rate (RR), PaCO ₂ , no significant changes in FRC
3	1967	Effect of pursed lips expiration on the pulmonary pressure-flow relationship in obstructive lung disease. <i>Am Rev Respir Dis</i> , 96(3)	15	Airway pressure inspiratory and expiratory	Yes. PLB group (8) and non PLB (7)
4	1983	Absence of nasal air flow during pursed lips breathing: The soft palate mechanisms. <i>Am Rev Respir Dis</i> , 128(4)	6	In all patients, cineradiographic studies showed during the expiratory phase of PLB that the soft palate rose to closely contact the posterior pharyngeal wall, completely occluding the entrance to the nasopharynx.	Yes. All six patients were naturally using PLB vs. anatomic structure
5	1989	A new pendant oxygen-conserving cannula which allows pursed lips breathing. <i>Chest</i> , 95(4)	9	The purpose of the study was to evaluate a oxygen delivery system and cost saving in pursed lips breathing population	No. PLB was not the focus of the study other than used in the instruction.
6	1989	Efficacy of a pulsed oxygen delivery device during exercise in patients with chronic respiratory disease. <i>Chest</i> , 96(3)	12	PaO ₂	No. PLB was used in the instruction but not as a study variable. The device will provide O ₂ when the body oxygen demand is increased
7	1991	Application of pursed lips breathing to chronic obstructive pulmonary disease patients with respiratory insufficiency. <i>Zhonghua Jie He He Hu Xi Za Zhi</i> , 14(5)	18	PLB can decrease RR, and pco ₂ and increased tidal volume and PaO ₂ .	Yes.
8	1997	Ambulatory sports in asthma improves physical fitness and reduces asthma-induced hospital stay. <i>Pneumologie</i> , 51(8)	31	Hospitalization days and cardiorespiratory fitness	Yes. Physical training including PLB
9	1998	Effects of a short-term pulmonary rehabilitation program on patients with chronic respiratory failure due to pulmonary emphysema. <i>Nihon Koryu Gakkai Zasshi</i> , 36(8)	15	Relieves dyspnea, increase functional exercise capacity, and decreases TLC and RV	Yes. Pursed lip breathing, diaphragmatic, respiratory muscle stretch gymnastics and walking with synchronized breathing altogether
10	1998	Effects of bathing on lung mechanics in patients with severe COPD <i>Nihon Koryu Gakkai Zasshi</i> , 36(2)	26	O ₂ sat	Yes. Combining with posture change, slow movements, and pursed lip breathing
11	2001	The effects of pulmonary rehabilitation with chronic obstructive pulmonary disease (COPD)	7	Increased 6 min walking, improve dyspnea and O ₂ saturation	Yes. Pursed lip breathing, relaxation, and diaphragmatic breathing, panic control, muscle stretch gymnastics and exercise training.
12	2001	Effect of expiratory resistance on gas-exchange and breathing pattern in chronic obstructive pulmonary disease (COPD)	10	PO ₂ and PCO ₂	Yes. Resistance applied during the weaning process in the intubated patient
13	2003	Comparison of the oxygen cost of breathing exercises and spontaneous breathing in patients with stable chronic obstructive pulmonary disease <i>Phys Ther</i> , 83(5)	30	VO ₂ and RR were lower during breathing exercises	Yes. 3 groups: pursed lips, diaphragmatic and combination of DB and PLB. The combined groups has the least RR

#	Year	Title / Journal	Sample size	Key research variables studied	Pursed lips and settings
14	2005	Effects of imposed pursed-lips breathing on respiratory mechanics and dyspnea at rest and during exercise in COPD. <i>Chest</i> , 128(2)	8	PLB improves dyspnea, increase end expiratory lung volume and tidal volume and lung capacity	Yes.
15	2005	An evaluation of the acute impact of pursed lips breathing on walking distance in nonspontaneous pursed lips breathing chronic obstructive pulmonary disease patients <i>Chron Respir Dis</i> , 2(2)	69	PLB Improve dyspnea, RR, and increase exercise tolerance in those who are not spontaneously PLB.	No to natural PLB (15) and yes to taught PLB (48)
16	2007	Efficacy of pursed-lips breathing: a breathing pattern retraining strategy for dyspnea reduction. <i>J Cardiopulm Rehabil Prev</i> , 27(4)	40	PLB decrease exertional dyspnea and improve physical function	Yes.
17	2008	Influence of spontaneous pursed lips breathing on walking endurance and oxygen saturation in patients with moderate to severe chronic obstructive pulmonary disease <i>Clin Rehabil</i> , 22(8)	32	Improve exercise dyspnea and oxygen desaturation	Spontaneous vs. non-spontaneous group randomized open-label, cross-over
18	2008	A randomized controlled trial study of pulmonary rehabilitation with respiratory physiology as the guide on prognosis in patients with chronic obstructive pulmonary disease <i>Zhongguo Wei Zhong Bing Ji Jiu Yi Xue</i> , 20(10)	60	Decrease dyspnea, improves ADL, QOL, exercise tolerance, and function of respiratory muscle	Cross sectional with three even groups (respiratory physiology, PLB, and none pulmonary rehab)
19	2010	Factors discriminating spontaneous pursed-lips breathing use in patients with COPD. <i>COPD</i> , 7(4)	57	Spontaneous PLB use during exercise with improvement on FEV1/FVC and the slope relating dyspnea to Ve.	Yes.
20	2014	A unidirectional breathing pattern improves breathing efficiency in subjects with severe COPD <i>Respir Care</i> , 59(10)	16	Reduction in functional dead space volume in the UB group	No. Unidirectional breathing (UB), nose-in mouth-out (NMB) or vice versa
21	2014	Effect of pursed-lip breathing in patients with COPD: Linear and nonlinear analysis of cardiac autonomic modulation <i>COPD</i> , 11(1)	32	Improving heart rate variability and affecting the behavior of the autonomic nervous system	Yes.
22	2015	Dynamic laryngeal narrowing during exercise: a mechanism for generating intrinsic PEEP in COPD? <i>Thorax</i> , 70(3)	19	During exercise, laryngeal narrow inversely related to FEV1 and peak O2 uptake	No.
23	2015	Pursed lip breathing improves exercise tolerance in COPD: a randomized crossover study. <i>Eur J Phys Rehabil Med</i> , 51(1)	40	PLB decrease expiratory peak flow and respiratory rate, improving exercise tolerance, and arterial oxygenation	Yes.
24	2016	Pursed-lips breathing reduces dynamic hyperinflation induced by activities of daily living test in patients with chronic obstructive pulmonary disease: A randomized cross-over study. <i>J Rehabil Med</i> , 47(10)	25	PLB reduced hyperinflation, but not improving 6MWT nor function capacity.	Yes.
26	2016	Do COPD patients taught pursed lips breathing (PLB) for dyspnoea management continue to use the technique long-term? A mixed methodological study. <i>Physiotherapy</i> , May 27.	13	PLB was reported effective by 8 patients by reducing the RR and increasing the SpO2. Qualitative data emerged as PBL improving physical activity and confidence in self-management.	Yes.