Pursed Lips Breathing Training Using Ear Oximetry

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Pursed lips breathing (PLB) training is often used in the management of patients with chronic obstructive lung disease (COLD). Previous clinical studies have demonstrated that PLB improves arterial oxygen saturation (SaO₂) and CO₂ removal as well as relieving dyspnea. Twelve hypoxemic subjects with stable COLD were randomly assigned to either the pursed lips (P) or control group consisting of general relaxation (R). The SaO₂ was monitored via ear oximetry, and respiratory rate and tidal volume were monitored using a strain gage transducer and the minute volume was calculated. The PLB was taught by an experienced instructor using the ear oximeter as a monitoring display with a goal toward increasing SaO₂. The subject was taught general relaxation (RLX) with the aid of pleasant music. We compared PLB and RLX treatments using an A-B-A crossover study design. In both groups, PLB significantly improved SaO₂ over baseline (p<0.001) whereas RLX did not. We conclude that patients can learn to increase their SaO₂ by PLB using ear oximetry adjunctively.

Pulmonary education programs often teach patients with chronic lung disease methods to improve the effectiveness of their breathing. The rationale for such breathing retraining can be compelling and many patients enjoy subjective improvement. Within the clinical setting, there is generally no way of determining whether a physiologic benefit has been achieved. One breathing retraining method enjoying recent popularity is pursed lips breathing. Using this method, subjects are instructed to purse their lips during exhalation so as to apply a back pressure. Pursed lips breathing has been shown to improve arterial oxygenation, reduce CO₂ levels, and provide subjective benefit to the subject.1,4

Clinically, the goal of pursed lips training is to achieve subjective benefits such as reduced dyspnea and an ability to control situations ordinarily resulting in panic. Clinicians and patients alike often assume that subjective benefits will be accompanied by appropriate physiologic changes. However, some previous studies suggest that subjective and physiologic responses may not be closely tied.1,7 Until recently, there have been no convenient means of measuring physiologic changes such as arterial oxygenation within the clinical setting. Now accurate ear oximeters which are easy to apply and require little therapist skill to operate are available. They reflect not only arterial oxygen saturation (SaO₂) but trends as well, and thus, may find use as a training adjunct to pursed lips breathing. In the following study, we examined the use of ear oximetry in conjunction with pursed lips breathing to improve SaO₂ while also investigating the concomitant response of tidal volume and respiratory rate.

METHODS

Twelve subjects with stable chronic obstructive lung disease who were hypoxemic at rest or low level exercise were asked to volunteer for the study. Mean descriptive statistics were: age, 67±5.2 years; FVC, 1.75±.9 L; FEV₁, 0.75±.4 L; and SaO₂, 91.1±2.5 percent. None of the subjects had experienced pursed lips breathing training within a year of the study and they were neither naturally nor by training, pursed lip breathers. They were presently nonsmokers and had no intimate contact with second hand smoke within two hours of the study. All patients were on a stable regimen of medication; however they were not allowed to take inhaled bronchodilators within one hour of the study.

An ear oximeter was used to monitor SaO₂ and a spirometrically calibrated vest pneumograph (custom designed by B.L.T. for this study) was used to measure tidal volume and respiratory rate noninvasively. Minute volume was calculated from the tidal volume and respiratory rate. A two-channel strip chart recorder provided a continuous write-out of SaO₂ and respiratory mechanics.

The 12 subjects were randomly assigned to the pursed lips and control groups with six subjects in the pursed lips group and six subjects in the control group. They were informed that they were participating in a study to evaluate the effects of two techniques to improve restful breathing. The control consisted of relaxation in which we simply asked the subject to relax with the aid of soft background music. The investigators gave the subjects the strong suggestion that relaxation will improve their breathing status. It was explained that people require less oxygen when they are in a relaxed wakeful state. The subjects did not watch the oximeter display during relaxation. The pursed lips session consisted of teaching pursed lips breathing with the subject and the teacher using the oximeter to monitor SaO₂ response to their efforts. The teacher was a
The two subject groups are compared in Table 1. Their mean ages, spirometric indices, and SaO2 were not significantly different. The responses of the physiologic variables to relaxation and pursed lips breathing are compared in Tables 2 and 3. In both groups, pursed lips breathing significantly improved SaO2 over relaxation and baseline values (p<0.001). Relaxation did not significantly improve SaO2 over baseline. Pursed lips breathing was accompanied by both a significant increase in mean tidal volume (p<0.01) and a significant decrease in mean respiratory rate (p<0.001). There was no significant difference in the mean minute volume between the two groups or within the same groups.

The change in SaO2 by pursed lips breathing and relaxation in both groups is demonstrated in Figure 1. In the pursed lips group, SaO2 was improved over baseline by pursed lips breathing, reduced to baseline during relaxation, and then increased again by pursed lips breathing. In the relaxation group, SaO2 was unchanged over baseline by relaxation, improved by pursed lips breathing, and reduced again during relaxation. There appears to be no carryover effect of either pursed lips breathing or relaxation. The increase in SaO2 from pursed lips breathing lasted only as long as the subject was performing the pursed lips maneuver. Within ten minutes of discontinuing pursed lips breathing, the SaO2 in every subject returned to baseline.

The relationships of pursed lips breathing and relaxation with tidal volume for each subject are shown in Figure 2. Pursed lips breathing was accompanied by an increase in tidal volume in both groups and relaxation was accompanied by a reduction in tidal volume in both groups. Again, there was no carryover effect of either treatment in either direction.

The relationships of pursed lips breathing and relaxation with respiratory rate for each subject are shown in Figure 3. Pursed lips breathing was accompanied by a

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**Table 1—Demographic Data for the Two Subject Groups**

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>FVC (L)</th>
<th>FEV1 (L)</th>
<th>SaO2 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pursed lips</td>
<td>64.7±4.0</td>
<td>1.8±0.8</td>
<td>91.5±3.0</td>
</tr>
<tr>
<td>Relaxation</td>
<td>69.0±5.7</td>
<td>1.7±1.1</td>
<td>91.6±2.0</td>
</tr>
</tbody>
</table>

**Results**

*P<0.001.  †P<0.01.

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**Table 3—Physiologic Response to Pursed Lips Breathing and Relaxation in Relaxation Group**

<table>
<thead>
<tr>
<th>Relaxation Group</th>
<th>Relaxation</th>
<th>Pursed Lips Breathing</th>
<th>Relaxation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SaO2 (%)</td>
<td>91.5±3.0</td>
<td>94.1±1.8†</td>
<td>90.8±2.2*</td>
</tr>
<tr>
<td>Tidal volume (L)</td>
<td>.5±1</td>
<td>1.1±0.3†</td>
<td>.4±.1†</td>
</tr>
<tr>
<td>Respiratory rate</td>
<td>17.7±4.0</td>
<td>7.8±1.5*</td>
<td>18.7±4.4*</td>
</tr>
<tr>
<td>Minute volume (L)</td>
<td>8.8±2.8</td>
<td>8.6±2.8</td>
<td>7.5±2.4</td>
</tr>
</tbody>
</table>

*p<0.001.

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Figure 1. The effect of pursed lips breathing and relaxation on arterial oxygen saturation.
The effect of pursed lips breathing and relaxation on respiratory tidal volume. Decrease in respiratory rate in both groups, and relaxation was accompanied by an increase in respiratory rate in both groups. There was no carryover effect of either treatment in either direction.

Minute volume was compared during pursed lips breathing and relaxation. There was no significant difference in the mean minute volume during either treatment.

Discussion

This study demonstrates that patients can learn to improve arterial oxygen saturation by the simple maneuver of pursed lips breathing exclusive of breathing supplemental oxygen. The ear oximeter was used to focus the subject and the therapist on SaO₂, as well as providing the measurement tool for the study. The digital readout was their guide since it provided continuous flow of valuable information. Thus, the nurse had the opportunity to immediately give encouragement to the subject when making a successful attempt at pursed lips breathing or discourage the subject from pursuing a fruitless direction. We made no attempt to compare SaO₂ changes using ear oximetry augmented training vs pursed lips breathing training alone. The addition of the ear oximeter might be the shortcut which allowed our subjects to consistently achieve improvement in SaO₂ within the short span of the 15-minute training session, although further studies will be necessary to make this determination. It is also noteworthy that their SaO₂ returned to baseline levels as soon as they ceased pursed lips breathing.

The improvement in SaO₂ from pursed lips breathing was large. The mean increase in SaO₂ over both baseline and relaxation was greater than 4 percent. This is consistent with the 3.3 percent increase seen by Mueller et al² and is not only physiologically significant but also clinically significant.

The control arm consisted of relaxation assisted by soft and pleasant music. The subjects were not given the impression that relaxation was less important than pursed lips breathing. Relaxation was simply a well-regarded technique known to relieve shortness of breath. They were told that we simply wished to evaluate the two techniques for improving breathing. Compared to pursed lips trials, the control was truly relaxing. Our subjects did not find pursed lips breathing natural, partly resulting from the fact that they were chosen because they were not normal pursed lips breathers.

Pursed lips breathing is strongly subjective for both the trainer and the patient responding to it. There have been a number of studies which have demonstrated that pursed lips breathing can improve arterial blood gases facilitating both oxygenation and CO₂ elimination.¹ Methods of training probably vary widely. Because we used an ear oximeter to facilitate training, we may be reporting on a technique sufficiently unique as to confound attempts to compare our findings with those of previous studies. Our subjects were chosen from a population of COPD patients who were not pursed lips breathers, and they did not take to our pursed lips training naturally despite the fact that they all improved their SaO₂ using the technique. Each subject appeared to work especially hard in accomplishing the SaO₂ increase and were more successful using forceful pursed lips maneuvering than the usual delicate backpressuring used by many patients considered natural pursed lips breathers. We also noted that some subjects were too forceful and thereby lowered their SaO₂, a situation easily perceived by both the subject and the nurse and rapidly remedied.

Our study found that successful pursed lips breathing was accompanied by markedly increased tidal volume and reduced respiratory rate with no consistent change in minute volume. These findings are

![Figure 2](image2.png)

![Figure 3](image3.png)
consistent with previous studies. Perhaps Motley addressed this issue most directly. He looked at slow deep breathing comparing it with intermittent positive pressure compressed room air (20 cm. H2O) breathing. His subjects improved both their SaO2 and carbon dioxide elimination using slow, deep breathing. Similarly, he discovered the same benefits but of even greater magnitude could be achieved using compressed air IPPB. Motley concluded that both techniques were useful in improving ventilation of slow-space (poorly ventilated alveolar units).

The question of the effect of increased oral pressure was addressed by Schmidt et al. They concluded that the benefit of pursed lips breathing related not to the oral pressure but to a reduction in the initial expiratory flow rate which would reduce the Bernoulli effect on small collapsible airways. They noted that normal subjects and asthmatics experienced no obvious benefit from pursed lips breathing.

Thoman et al. found that tidal volume increased while respiration rate decreased and CO2 elimination improved using pursed lips breathing. Additionally, they found that there was an increase in slow-space ventilation again concluding that intra-airway pressure was not responsible for blood gas improvement. The effect of increasing the tidal volume would be an alteration of Vd/Vr in favor of an earlier presentation of oxygen in inspiration.

Mueller et al. studied the effects of pursed lips breathing on COPD subjects who claimed benefit vs those who did not feel benefit from pursed lips breathing both during rest and exercise. They again observed that pursed lips breathing was accompanied by both increased tidal volume and decreased respiratory rate, although more so in the subjects who claimed benefit from pursed lips breathing. Mueller et al. also reported improved arterial oxygen and carbon dioxide tensions in both groups during rest but not during exercise. They again concluded that the benefit of pursed lips breathing was due to decreased airway collapse, decreased respiration rate, and increased tidal volume. They further found that there was no relationship between symptomatic benefit from pursed lips breathing and improvement in arterial blood gases. Mueller et al., as well as other investigators, found that although pursed lips breathing was more effective in the sense that less air exchange was required to absorb a given amount of oxygen, there was no increase in oxygen uptake. This suggests that pursed lips breathing does not significantly alter the work of breathing. We did not measure the work of breathing; however, our subjects appeared to work harder during each pursed breath although their minute ventilation did not increase.

Our findings indicate that pursed lips breathing training with the adjunct of ear oximetry is a useful technique for temporarily improving SaO2 and lends physiologic support for its clinical use. One might speculate that when patients have the knowledge that they can increase the oxygenation of their blood by a simple breathing technique, they might not panic during times of respiratory distress. Thus, self-confidence could be improved, as well as patient quality of life. Long-term studies are recommended to determine if there are any lasting benefits to pursed lips breathing.

REFERENCES

4. Petty TL, Guthrie A. The effects of augmented breathing maneuvers on ventilation in severe chronic airway obstruction. Respir Care 1971; 16:104-11