

Specially Programmed Respiratory Muscle Training for Singers by Using Respiratory Muscle Training Device (Ultrabreathe[®])

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Respiratory muscle training is one of the major methods for enhancing the vocal function. Singers who must use their voice most frequently are well aware of the importance of respiration. However, most of them do not know precisely how to exercise their abdominal respiration. Using a respiratory training device, singers are expected to gain more efficiency in their vocal enhancement. The aim of the study was to examine the pulmonary function, the maximum inspiratory pressure (MIP) and the maximum expiratory pressure (MEP), and the maximum phonation time (MPT) in five female voice-majors students after undergoing specially programmed respiratory muscle training for 2 months. All the voice-majors had an average of 4.8 years of formal classical voice training. A respiratory muscle training device (Ultrabreathe[®]), Tangent health Care Inc., England) was used to train the respiratory muscle. None of the pulmonary function test variables had changed after respiratory muscle training. However, the MIP, MEP, and MPT were significantly increased higher after the respiratory muscle training. This suggests that the specially programmed respiratory muscle training can improve the respiratory muscle strength and vocal function without increasing the pulmonary function.

Key Words: Respiratory muscle training, maximum inspiratory pressure, maximum expiratory pressure, maximum phonation time, singing population

INTRODUCTION

Respiration is one of the most important elements for making voices, and a drop in respira-

tory function, which is the power source of the voice, will have a significant effect on the voice. For improving the voice production, strengthening respiratory muscles with exercises,^{1,2} proper posture, and vocal function exercises³⁻⁵ have been emphasized. However, the general public does not adequately appreciate the importance of the respiratory function because respiration is used unconsciously in our daily life. Singers who should use their voice most intimately are well aware of the importance of respiration, and they spend a number of hours in their respiratory training. However, most singers do not know exactly how to exercise their respiration and by what technique.

General respiration methods are described as chest, abdominal, and chest-abdominal respirations, and classical singers are advised to practice abdominal respiration as their a breathing method. Abdominal respiration, which is also called diaphragmatic respiration, is means to breathe by using the diaphragm as the chief muscle. During inspiration, the muscle diaphragm plays the largest part (about 80%), while the thoracic and other respiratory muscles assume responsibility of the rest. During expiration, the epigastric muscles play the largest part (about 80%), while the thoracic and other respiratory muscles assume responsibility of the rest.^{1,6}

Training the respiratory pressure trains the maximum inspiratory pressure (MIP), which represents the diaphragmatic pressure, and the maximum expiratory pressure (MEP), which represents the epigastric pressure.⁷ The maximum

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phonation time (MPT) is widely used as a simple clinical test for appraising the function of the vocal cord,⁸ however, a question of whether the MPT is actually related to the respiratory muscle strength has not yet answered. In this study, the inspiratory and expiratory muscles have been shown to be specifically trained along with the improvement of the muscle strength and endurance.⁹ The degree of improvement was dependent on the amount of resistive load during the conditioning.¹⁰

A respiratory muscle training device with a resistive load has been used by athletes as well as patients with obstructive pulmonary disease, neuromuscular disease, and upper airway insufficiency.^{9,11-14} Using an aid for respiratory training, which was originally devised to be more convenient to athletes or the public in their respiratory training, it is expected that singers will also gain more vocal efficiency. Therefore, in this study the voice-majors trained by intensifying their respiratory muscles with using an aid for respiratory training (Ultrabreathe®), Tangent Health Care Inc., Peterborough, England), while their old way of exercising respiration was carried out concurrently. Subsequently, we introduced the specially programmed respiratory muscle training. By comparing the differences in the respiratory pressure before and after the training and along with the possible variations in MPT, we tried to find out whether this training helped intensify the respiratory muscles.

MATERIALS AND METHODS

Investigative subjects

Five female voice-majors, who were currently

studying classical vocal music with awareness of the importance of respiratory training and willingness to take the training, were enrolled in this study. Their average age was 23 years, and they had studied classical vocal music for 4.8 years, and had no history of respiratory or voice disorders (Table 1).

Methods of exercising respiration with Ultrabreathe®

Respiratory training was held for approximately 2 months, from July 14 through September 15, 2003. Ultrabreathe® (Tangent health Care Inc., England) was used as the our aid for respiratory training (Fig. 1). In actual respiratory training, the subjects were advised to increase resistance by adjusting the lever in their mouths (Fig. 2). In the 1st week, the subjects were autonomously using only Ultrabreathe® 7 to 10 times a day, for 5 to 10 minutes at each time. In the 2nd and 3rd week, staying in a music camp, the program was carried with Ultrabreathe® in the mouth for approximately 60 to 90 minutes as our respiratory training



Fig. 1. Respiratory muscle training devices (Ultrabreathe®).

Table 1. Physical Characteristics of All the Subjects

Subject	Age (year)	Height (cm)	Weight (kg)	Year of Training	Vital capacity (L)	Vital capacity (% pred.)
1	20	164	53	3	3.69	105
2	21	164	60	2	4.56	114
3	23	163	51	6	2.95	74
4	23	162	50	7	3.88	98
5	28	159	48	6	2.66	73



Fig. 2. Respiratory muscle training with Ultrabreathe®.

program as follows. At the same time, vocal training was taken all throughout the camping session. In the 4th week and for the next one month, an autonomous training was performed with using only Ultrabreathe® 7 to 10 times a day, for approximately 10 minutes at each time.

Our respiratory training program

This program was specially designed for singers by modifying and systematizing the classic Italian belcanto methods. This method was classified into two positions; that is standing and lying, and was convenient with using muscle training devices.

Method for training in the standing position

- 1) During inspiration in slowly, the arms are raised slowly. The breath is held for a moment, and the arms are lowered slowly in expiration keeping the chest extended.
- 2) The subjects inspire in slowly and hold the breath for a moment. With the strength on the lips, the subjects then expire slowly (with a /s/ sound).
- 3) The ends of the hands are placed between the navel (the center of the abdominal region) and the pit of the stomach, and the subject inspires slowly. The breath is held for a moment, and the subjects then expire slowly with an effort to keep the ends of the hands still separated.
- 4) The subjects inspire slowly and hold the breath for a moment. After counting 1-2-3 in mind, the subjects expire a short breath and then, counts 1-2-3 and expire short again. This procedure is repeated again.
- 5) The subjects inspire short, and after counting 1-2-3 in mind, inspire short again. The subjects count 1-2-3 again and repeat. Then, after holding the breath for a moment, the subjects expire a short breath. This procedure is repeated twice.
- 6) The subjects inspire by dividing the breath in three. The breath is held for a moment and then expired slowly.
- 7) The subjects inspire by dividing in three. The breath is held for a moment and then expired dividing in three.
- 8) Practice 7) successively without a pause.
- 9) The subjects breathe in long and softly in inspiration, and breathe out short and strongly at one time in expiration.
- 10) The mode of respiration can be changed such as short and strong inspiration - long and soft expiration, long and soft inspiration - long and soft expiration and short and strong inspiration - short and strong expiration.
- 11) In inspiration, the subjects breathe in slowly in adjustment for 20 seconds and hold the breath for 20 seconds. During holding the breath, some is given force to the upper abdomen while relaxing the other parts. The subjects then expire over a period of 4 seconds.
- 12) The time for respiration is extended as follows; inspiration for 30, 40, 50 seconds - holding for 30, 40, 50 seconds - expiration for 5, 6, 7 seconds.
- 13) The subjects cross their legs like scissors and sticks them fast to each other. Their lower abdomen and legs are strained strongly and the respiration is exercised for 4 to 10 times.
- 14) The upper body is lowered with the subjects' hands on their knees. With a sense of the back part of their waist extended, the subjects breathe in and then out slowly.
- 15) The subjects hold both hands to the back part of their waist. The subjects inspire slowly while lowering their upper body slowly with a sense of the back part of their

waist extended. The breath is held as long as possible and let it out slowly while straightening up the waist.

- 16) The subjects inspire while twisting their waist sideways. This position is held for a moment, and then the subjects expire while twisting their waist in the opposite direction. (with a movement of the arms and shoulders in the same direction)

Method for training in the lying position

- 1) With a slow inspiration, the subjects raise one leg, hold this position for a moment and lower the leg with a expiration. The legs are alternated in the same way.
- 2) With a slow inspiration, the subjects raise both legs, hold for a moment, and lower the legs with a expiration.
- 3) The subjects inspire with their legs bent at 45 degrees while swelling the abdomen and sides. With a expiration, the legs are straightened up forward and the upper body is raised.
- 4) Lying on one side with the left arm under the head, the subjects cross their legs and place their right hand on the side. With a inspiration, the side is swelled up, held for a moment, and expired slowly. Do it over by switching the position.
- 5) The subjects inspire and swell up the abdomen and sides with their legs bent at 45 degrees. While breathing out, the subjects straighten up the legs forward and raise the upper body.
- 6) Lying on one side with the left arm under the head, the subject cross their legs and places their right hand on the side. With a inspiration, one is swelled up, held for a moment, and expired slowly. This procedure is repeated by switching the position.
- 7) After bending their legs, the subject inspires while raising a part of pelvis slowly. This position is held for a moment, and then placed them back.

Test of pulmonary function

Two-time tests of pulmonary function were

performed before and after the respiratory training. The first was carried out immediately before the training with only Ultrabreathe®, and the second test was performed 8 weeks later, when all the training sessions had been completed. The tests were performed at the Respiratory Center of the Yongdong Severance Hospital, where the flow volume curve was measured by Vmax 6200 of Sensor Medics Inc., and the body plethysmography was carried out by using an Autobox (Fig. 3).

Test of respiratory muscle strength

The respiratory muscle strength was examined twice. On the first test, the maximum static pressure, MIP and MEP, were measured before the beginning of the respiratory training, and the second one was measured after 2 months of respiratory training by using Ultrabreathe®. The MIP and MEP were measured by using Spirovis® (Cosmed Inc., Roma, Italy) as follows (Fig. 4). In order to measure the MIP, the subjects in the standing position were advised to exhale as slowly as possible almost to the residue of the lungs and then inhale as strongly as possible through a mouthpiece connected to Spirovis®. In order to measure the MEP, they were advised to inhale as much as possible almost to the maximum lung capacity and then exhale as strongly as possible through a mouthpiece connected to Spirovis®. At each measurement, the maximum pressures lasting for at least one second were recorded. During the test, the measurements were



Fig. 3. Pulmonary function test.

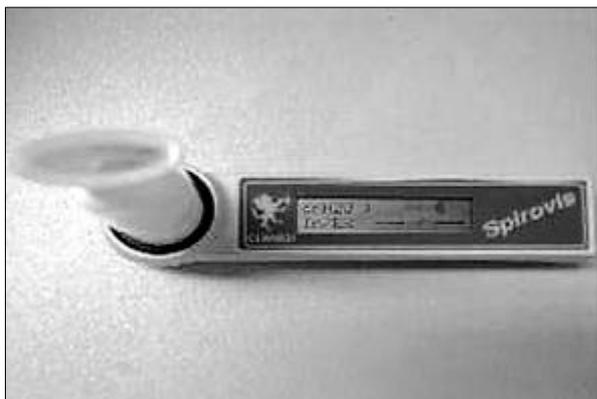


Fig. 4. Measurement of the maximum inspiratory pressure and maximum expiratory pressure using Spirovis®.

taken 5-times, and the mean of remaining three measurements were taken with the exception of the maximum and minimum values.

Measurement of maximum phonation time (MPT)

The maximum phonation time was measured by the using of a micro chronometer that can measure up to 0.01 seconds. In the test, the subjects were advised to inhale sufficiently in a straightly standing position and say /a/ sound with a comfortable pitch of their free choice. The MPT was measured 3 times in total, and the largest value was taken.

Statistical analysis

A paired T-test was performed for the statistical analyses of MEP, MIP, MPT and pulmonary function before and after respiratory training by using Statistical Packages for a Social Science (SPSS, ver. 11.5) statistical program. For significance level, the value of " p " ≤ 0.05 was considered as statistically significant differences.

RESULTS

The values for the forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), FEV1/ FVC and forced expiratory flow (FEF 25 - 75%), which are simple tests for the pulmonary

function, were found to be statistically similar before and after the respiratory training. In addition, the values for the total lung capacity (TLC) and vital capacity (VC), which are the special tests of the pulmonary function, were not significantly different before and after the training (Table 2).

The MIP showed statistically significant differences between before (62.2 ± 13.5 cmH₂O) and after (78.2 ± 3.7 cmH₂O) the respiratory training, and the MEP also showed statistically significant increases after the respiratory training (56.4 ± 7.5 cmH₂O vs 70.0 ± 8.1 cmH₂O). Such statistically significant increases were also observed in the MPT - before the respiratory training (22.3 ± 4.3 sec) but after (31.0 ± 6.7 sec) - a statistically significant increase (Table 3).

DISCUSSION

In this study, a specially programmed respiratory muscle training method was shown to increase the respiratory muscle strength in a short period of time. With using the training device, which has been used for subjects with obstructive pulmonary disease such as emphysema,^{9,12} the respiratory muscle strength was improved in these experimental group. In addition, this training can easily be performed and does not require a great deal of times. This can be beneficial to singers aiming to improve their voice production and might serve as a model for similar training or an additional training program to be added to the other approaches.

The results of this study showed little differences in the pulmonary function before and after respiratory training, even after the respiratory training were combined with its aiding apparatus. The subjects of this research had approximately 4.8 years of vocal training. However they showed no differences in the pulmonary function from the general female.¹⁵ Trumpet players have also been reported to show a similar difference in the pulmonary function, compared to the untrained ordinary people.¹⁶ Likewise, after 4-weeks training of elementary long-distance athletes, they showed no differences in the pulmonary function before and after 4-weeks training.¹⁷ On the other hand, however, earlier dissertations by Gould et

Table 2. Pulmonary Function Test Variables between the Pre-Training and Post-Training Group

Characteristics		Pre-Training	Post-Training
FVC	Liters	3.5 ± 0.7	3.5 ± 0.8
(% predicted)	(%)	90.8 ± 17.6	92.6 ± 20.7
FEV1	Liters/sec	3.0 ± 0.5	3.1 ± 0.5
(% predicted)	(%)	95.2 ± 11.8	96.4 ± 12.8
FEV1/FVC	%	88.2 ± 6.7	88.0 ± 7.1
FEF25-75%	Liters/sec	3.7 ± 0.6	3.8 ± 0.6
(% predicted)	(%)	88.2 ± 9.4	104.0 ± 29.5
TLC	Liters	4.6 ± 0.6	4.6 ± 0.6
VC	Liters	3.5 ± 0.8	3.6 ± 0.8
IC	Liters	2.4 ± 0.6	2.3 ± 0.5
FRC	Liters	2.1 ± 0.4	2.2 ± 0.2
ERV	Liters	1.2 ± 0.6	1.2 ± 0.3
RV	Liters	1.0 ± 0.3	1.0 ± 0.3
Vtg	Liters	3.2 ± 0.5	2.9 ± 0.6
Raw	cmH ₂ O/L/sec	1.1 ± 0.1	1.4 ± 0.5

Data are expressed as mean ± SD.

FVC, forced vital capacity; FEV1, forced expiratory volume in 1 second; FEF, forced expiratory flow; TLC, total lung capacity; VC, vital capacity; IC, inspiratory capacity; FRC, functional residual capacity; ERV, expiratory reserve volume; RV, residual volume; Vtg, volume thoracic gas; Raw, resistance of air way.

Table 3. Maximal Inspiratory Pressure (MIP), Maximal Expiratory Pressure (MEP), and Maximum Phonation Time (MPT) before and after Training Group

Characteristics		Pre-Training	Post-Training
MIP	cmH ₂ O	62.2 ± 13.5	78.2 ± 3.7*
MEP	cmH ₂ O	56.4 ± 7.5	70.0 ± 8.1*
MPT	sec	23.3 ± 4.3	31.0 ± 6.7*

Data are expressed as mean ± SD.

**p* < 0.05.

al.¹⁸ reported that singers have a higher pulmonary function than the ordinary people, which is different from the present study.¹⁵ To sum overall these observations, the subject group's pulmonary function does not appear to improve even in combination of respiratory training with its aiding apparatus.

As a result of combining respiratory training with its supplementary apparatus, we were able

to observe increases in the MIP and MEP after the training, which confirms that there has been an increase in the respiratory pressure. In this study, the pre-training values of the MIP and MEP for the students with 4.8 years of vocal training were similar to those of the untrained ordinary people.¹⁹ Furthermore, their post-training values were similar to those of the singers who had a career of 22.5 years.¹⁹

This study showed an approximate 26% increase in the MIP (78.2 ± 3.7 cmH₂O vs 62.2 ± 13.5 cmH₂O) after the training, which indicates that respiratory training does not alter the pulmonary function, but it can increase the respiratory muscle strength. Similar to these results, De Lucas et al.²⁰ reported that respiratory muscle training for cases of obstructive pulmonary diseases didn't alter their pulmonary function, but it increased the P_{lmax} (peak inspiratory pressure) significantly.

The subject who showed the lowest inspiratory pressure (44 cmH₂O) before the respiratory training showed the greatest increase of approximately 70% in her respiratory pressure (75 cmH₂O), the second with the least pressure (55 cmH₂O) showed an approximate 36% increase (75 cmH₂O) after the respiratory training, and the one with the least increase (4%, 84 cmH₂O) already showed a high value (79 cmH₂O) before the respiratory training. Although the number of samples was rather small, the results suggest that the less respiratory training one usually takes and the less training in the diaphragm, the greater can their MIP increase after respiratory training.

In this study, the MEP was found to increase some 25% after the respiratory training (70.0 ± 8.1 cmH₂O) than before (56.4 ± 7.5 cmH₂O). The MEP is the test representing the abdominal muscle strength, and its increase after respiratory training indicates that a singer lacking training can increase their abdominal muscle strength, if they undergo respiratory training according to a specially programmed method.

Indeed, regarding singers, MIP measurements are more useful than the MEP.⁹ This is because sufficient diaphragmatic muscle strength alone enables more air to be inhaled in inspiration, which, in turn, allows one to make good use of the air in affected singing. A decrease in the MIP is also used as an index to a weakening respiration.

In this study, the MPT was greatly increased (approximately 33%) after respiratory training (31.0 sec vs 23.3 sec). The MPT was directly related to VC, and it decreases in various cases of vocal cord diseases.²¹ On the other hand, Solomon et al.²² reported that there was no correlation between the VC and MPT, but that those who

show quite a long MPT use up to 90% of their VC. An earlier study revealed no correlation between the respiratory pressure and the MPT.¹⁹ Therefore, a large increase in the MPT after respiratory training is most likely due to an improvement in the regulation of respiratory and vocalis muscles as a result of respiratory training and vocal function exercises for 2 months.

In conclusion, specially programmed respiratory training, with a combined supplementary apparatus, did not cause any variations in the pulmonary function, but helped increase the respiratory muscle strength and increased the MPT. This method can easily be performed and does not require a great deal of times. Consequently, this can be beneficial to the singing population by improving voice production. However, because this program involves a short-term training and an increase in respiratory muscle strength does not make a good singing voice, it is believed that combination of respiratory and vocal training is more effective in improving vocal music. The effect of a long-term respiratory training makes still remains to be studied. In addition, further research should be designed to examine the efficacy of respiratory muscle training in the acoustic parameters and the effects when used on subjects with a voice-disorder.

REFERENCES

1. Watson P, Hixon T. Respiratory kinematics in classical (opera) singers. *J Speech Hear Res* 1985;28:104-22.
2. Boone D. Respiratory training in voice therapy. *J Voice* 1988;2:20-5.
3. Mendes AP, Rothman HB, Sapienza C, Brown WS. Effects of vocal training on the acoustic parameters of the singing voice. *J Voice* 2003;17:529-43.
4. Sabol J, Lee L, Stemple J. The value of vocal function exercise in the practice regimen of singers. *J Voice* 1995; 9:27-36.
5. Stemple J, Lee L, Amico B, Pickup B. Efficacy of vocal function exercises as a method of improving voice production. *J Voice* 1994;8:271-8.
6. Hixon T, Goldman M, Mead J. Kinematics of the chest wall during speech production: Volume displacements of the rib cage, abdomen, and lung. *J Speech Hear Res* 1973;16:78-115.
7. Karvonen J, Saarelainen S, Nieminen MM. Measurement of respiratory muscle forces based on maximal

- inspiratory and expiratory pressures. *Respiration* 1994; 61:28-31.
8. Isshiki N, Okamura H, Morimoto M. Maximum phonation time and air usage during phonation: simple clinical test for vocal function. *Ann Otol Rhinol Laryngol* 1967;76:998-1007.
 9. Weiner P, Magadle R, Beckerman M, Weiner M, Berar-Yanay N. Comparison of specific expiratory, inspiratory, and combined muscle training programs in COPD. *Chest* 2003;124:1357-64.
 10. Tzelepis G, Vega D, Cohen M, McCool F. Lung volume specificity of inspiratory muscle training. *J Appl Physiol* 1994;74:789-94.
 11. Power S, Howley E. *Exercise physiology: theory and application to fitness and performance*. 4th ed. New York: McGraw Hill; 2001.
 12. Harver A, Mahler DA, Daubenspeck JA. Targeted inspiratory muscle training improves respiratory muscle function and reduces dyspnea in patients with COPD. *Ann Intern Med* 1989;111:117-24.
 13. Gozal D, Thiriet P. Respiratory muscle training in neuromuscular disease. *Med Sci Sports Exerc* 1999;31: 1522-7.
 14. Baker SE, Sapienza CM, Martin D, Davenport P, Rudy BH, Woodson G. Inspiratory pressure threshold training for upper airway limitation: a case of bilateral abductor vocal fold paralysis. *J Voice* 2003;17:384-94.
 15. Nam DH, Ahn CM, Lim SE, Kang SW, Choi HS. Difference in respiratory function and vocal aerodynamics between professional sopranos and female subjects without vocal training. *J Korean Logo Phon* 2004;12:121-5.
 16. Fiz JA, Aquilar J, Teixido A. Maximum respiratory pressures in trumpet player. *Chest* 1988;104:1203-4.
 17. Williams JS, Wongsathikun J, Boon SM, Acevedo EO. Inspiratory muscle training fails to improve endurance capacity in athletes. *Med Sci Sports Exerc* 2002;33: 1194-8.
 18. Gould WJ, Okamura H. Static lung volumes in singers. *Ann Otol Rhinol Laryngol* 1973;82:89-95.
 19. Nam DH, Ahn CM, Lim SE, Kang SW, Choi HS. Maximal inspiratory pressure, maximal expiratory pressure, and maximum phonation time in singers, untrained ordinary persons, and patients with vocal cord diseases. *J Korean Logo Phon* 2002;13:117-23.
 20. De Lucas Ramos P, Rodríguez González-Moro JM, García de Pedro J. Training of inspiratory muscles in chronic obstructive lung disease. Its impact on functional changes and exercise tolerance. *Arch Bronconeumol* 1998;34:64-70.
 21. Hirano M, Koike Y, von Leden H. Maximum phonation time and air usage during phonation. *Folia Phoniatr* 1968;20:185-201.
 22. Solomon NP, Garlitz SJ, Milbrath RL. Respiratory and laryngeal contributions to maximum phonation duration. *J Voice* 2000;14:331-40.