Proceeding

An Eight-Week of Inspiratory Muscle Training Program Improved Chest Expansion in Subjects with Inspiratory Muscle Weakness: A preliminary study

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Background and Objective: Maximum inspiratory pressure (MIP) serves as an indicator of inspiratory muscle strength. It is still controversy whether an inspiratory muscle strength and chest expansion are improved after low resistive intensity of MIP training. This study aimed to examine whether 40% of MIP for 8 weeks training increase inspiratory muscle strength, chest expansion and diaphragmatic movement in subjects with respiratory muscle weakness.

Methods: Eight female subjects with respiratory muscle weakness, MIP less than 80% predicted, were recruited in this experiment. All subjects were measured MIP, upper chest, lower chest expansion, and diaphragmatic movement at baseline and post training. Respiratory muscle training program was performed by using a Threshold Inspiratory Muscle Trainer at 40% of MIP, 10 repetitions/set, 3 sets/day, 5 days a week, 8 weeks. MIP was evaluated weekly during a 8-week experimental period.

Results: It appears that the maximum inspiratory pressure progressively increased and sustained in the study subjects until the end of the training period. At the end of the training period, the MIP was higher than baseline values (-75.3 ± -10.2 cmH_2O vs. -92.8 ± -16.5 cmH_2O; p = 0.017). Moreover, a lower chest expansion (5.8 ± 1.4 cm vs7.3 ± 1.6 cm; p = 0.02) and diaphragmatic movement (4.6 ± 1.6 cm vs. 6.9 ± 1.5 cm; p = 0.007) were also increased after 8 weeks of training.

Conclusion: The findings of the current study suggest that inspiratory muscle training with 40% of MIP for 8 weeks improved inspiratory muscle strength and chest expansion in subjects with respiratory muscle weakness. The MIP training program may be useful for improvement of chest expansion in subjects, having an inspiratory muscle weakness.

Key words: Inspiratory muscle training, Maximum inspiratory pressure, inspiratory muscle weakness, six minute walk distance

Introduction

Chest physical therapy techniques such as breathing exercise, thoracic expansion exercise, and physical therapy devices commonly used to improve chest expansion for a variety of patients with respiratory diseases. Assessment of chest expansion is necessary to provide the patient's limitations and also useful in monitoring improvement during pulmonary rehabilitation.

Maximum inspiratory pressure (MIP) serves as an indicator of inspiratory muscle strength.Diminished inspiratory muscle strength has been reported in chronic diseases such as neuromuscular disorders[1], chronic kidney disease[2], chronic heart failure[3, 4], and chronic obstructive pulmonary disease (COPD)[5]. In addition, inspiratory muscle weakness was also observed in normal subjects and aging[6-8].

Movement of the rib cage and diaphragm during inspiration are important factors in the chest and lung expansion.The attenuation of inspiratory muscle contraction could be, in part,responsible for generatingminimal negative pressure in the pleural cavity and decreased lung volume[9]. Therefore, improve respiratory muscle strength causing increase volume of the thoracic cavity and associated with and the degree of chest expansion.

Previous studies showed inspiratory muscle strength has a positive correlation with chest expansion[8].Althoughinspiratory resistive load traininghas been reported to be improving inspiratory muscle strength, chest expansion and exercise capacity[2],the differences training program variable include frequency, volume, and intensity of training may provide different results.It is possible that, low resistive intensity (40% of maximum inspiratory pressure (MIP) for 8 weeksmay improve chest expansion and diaphragmatic movement in subjects with respiratory muscle weakness.

This study aimed to examine whether 40% of MIP for 8 weeks trainingcouldincreaseinspiratory muscle strength, chest expansion and diaphragmatic movement in subjects with respiratory muscle weakness.

Methods

Eight female subjects, who met the inclusion criteria were included: 1) respiratory muscle weakness, MIP less than 80% predicted[6, 10], 2) normal pulmonary function test, 3) BMI 17.5 – 22.9 kg/m^2, 4) exercise less than 50 minutes/week, and 5) Non-smoker. Exclusion criteria were excluded: 1) medical diagnosis of cardiovascular diseases and musculoskeletal disorder, 2) abnormal chest shape, and 3) refusal by an individual. All protocols were approved by the Institutional Ethics Committee of Burapha University (Reference No. 114/2559).

All participants in this study were measured baseline and post-training parameters, i.e.MIP, upper and lower chest expansion, and diaphragmatic movement.

MIP was evaluated by using respiratory pressure meter (*MicroRPM*™, CareFusion, UK) with a disposable cardboard mouthpiece. Each participant was asked to perform five MIP maneuvers, the highest three MIP values were averaged and recorded. The subject was seated for the test. The Physical Therapist first demonstrated the correct maneuver. The participant was instructed to exhale slowly and completely, seal lips firmly around the mouthpiece, and then take a hardly inhaled to the maximal amount of additional air that can be drawn into the lungs (inspiratory reserve volume). Each maneuver was sustained for at least one second and the participant was allowed to rest for one minute and then repeat the maneuver.

Pulmonary function test was performed in all subjects following the American standard for spirometry method[11].

Chest wall expansion was measured at the thoracic circumference by using rigid tape. Thoracic chest expansion was recorded three values of the differncebetween breathing out

maximally to breathing in maximally. Upper chest expansion was measured at axillary level, lower chest the tape measure was put at the tip of xiphoid tip, and diaphragmatic movement was placed at the lateral lower edge of the 10^{th} rib[8, 12].

After baseline parameters were collected, subjects were assigned to inspiratory muscle training program. Respiratory muscle training program was performed by using a Threshold Inspiratory Muscle Trainer (Powerbreathe K1series, England, United Kingdom) at the loading of 40% of MIP, 10 repetitions per set, 3 sets per day, 5 days per week. The participants were supervised by a researcher all of the training session. MIP was evaluated weekly during an 8-week experimental period.

Data were expressed as mean ± standard deviation (SD) and analyzed using SPSS software version 17. Comparisons between baseline and post training were performed using a paired-*t* test.$p<0.05$ was considered significantly different.

Results

General characteristics of the participants include age, height, weight, body mass index (BMI), and blood pressure were presented in Table 1. There were seen normal pulmonary function test of all subjects (Table 1).

Figure 1A showed the inspiratory muscle training program at 40% of MIP significantly increased MIP (increase more negative pressure) compared with baseline (-75.3 ± -10.2 vs. -92.8 ± -16.5; p = 0.017). Moreover, the results appear that the MIP progressively elevated at week 4 and sustained in the study subjects until the end of the training period (Figure 1B).

Interestingly, after MIP training was significantly increased lower chest expansion (5.5±1.7 vs. 7.3±1.6; p = 0.02) and diaphragmatic movement (4.6±1.6 vs. 6.9±1.5; p = 0.007) compared with baseline. (Figure 2)

Table 1 General characteristics of all subjects.

Parameters	All subjects (n=8)
Age (years)	20.5 ± 0.9
Height (m)	1.6 ± 0.1
Weight (kg)	50.1 ± 4.9
BMI (kg/m^2)	19.4 ± 1.7
Systolic blood pressure (mmHg)	104.8 ± 6.7
Diastolic blood pressure (mmHg)	70.3 ± 5.6
Pulmonary function test(%predicted)	
FVC	89.7 ± 10.5
FEV1	93.3 ± 10.1
FEV1/FVC	106.0 ± 4.4

Data were expressed as Mean ± SD. BMI; Body mass index, FVC; Force vital capacity, FEV_1; Force expiratory flow in 1 second

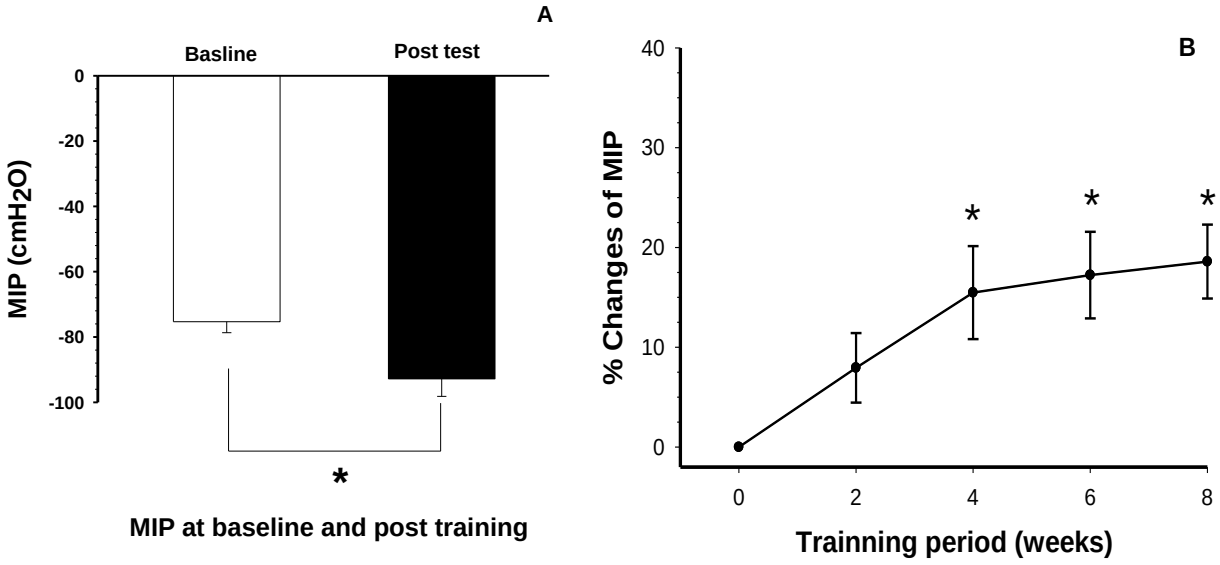

Figure 1 The effect of 40% MIP training on MIP at baseline and post training period (A), % changes of MIP during 8-week (B) experimental period. Data were expressed as mean ± SD. * p<0.05 compared with baseline.

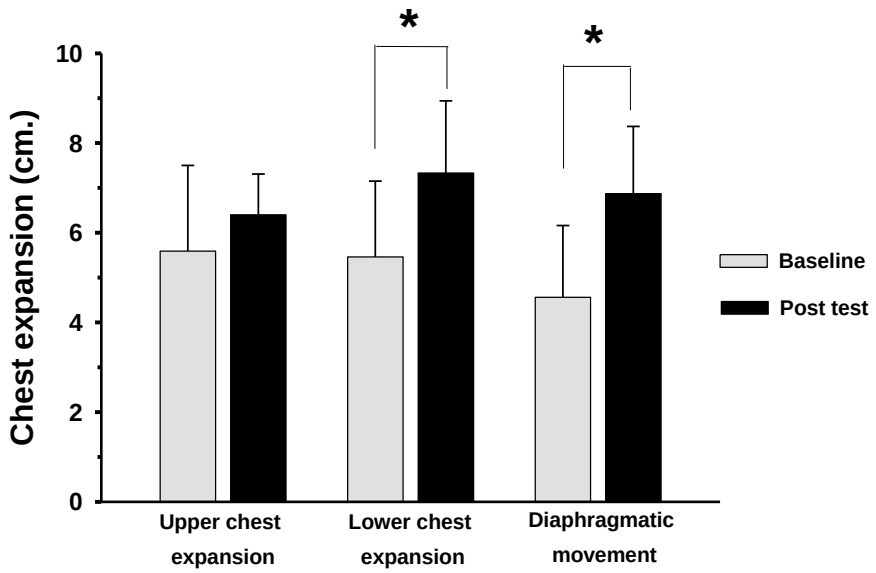

Figure 2 The effect of 40% of MIP training on upper chest, lower chest expansion and diaphragmatic movement at baseline and post training period. Data were expressed as mean ± SD. *p<0.05 compared with baseline.

Discussion

The main reported finding of this study is that, 8 weeks of 40% of MIP training were significantly increased MIP, lower chest expansion and diaphragmatic movement in subjects with

inspiratory muscle weakness, but upper chest expansion remained unchanges. Moreover, our data evidenced that the MIP were significantly elevated after 4 weeks of training period.

Maximal inspiratory pressure is an indicator of inspiratory muscle strength. Maximal inspiratory pressure is the amount of negative pressure, which is able to generate when trying to take a deep breath. Based on the pressure-volume relationship of the respiratory system, the higher of the lung volume associated with the higher inspiratory muscle strength. Diminished respiratory muscle strength could be affected by decreasing of chest expansion and lung volume. The results of the present study found MIP significantly increased after training. Similarly, previous work shown that 10 weeks of inspiratory muscle training at 40 -60% of MIP was significantly increased respiratory muscle strength in patients with Multiple Sclerosis[13]. In addition,8weeks program of inspiratory muscle training set at 80% of maximal effort in healthy subjects was improved vital capacity, total lung capacity, inspiratory muscle strength, and diaphragmaticthickness[14]. Therefore, increment of thoracic expansion and diaphragmatic movement may responsible for higher inspiratory muscle strength by improving inspiratory muscle thickness[14].

In many published studies report resistive inspiratory muscle training, improve maximum oxygen consumption and exercise capacity in healthy subjects[14], and also reduce dyspnea perception in patients with heart and lung diseases [5, 15].This result suggested resistive inspiratory muscle training may have a significant impact in improving lung expansion, and exercise capacity, and reduce dyspnea in subjects who have aninspiratory muscle weakness.

This study revealed that, low resistive inspiratory muscle training (40% of MIP) can improve respiratory muscle strength and chest expansion.Thus, this training method has recommended for therapists to apply in subjects, who have an inspiratory muscle weakness and diminish of chest expansion.

Conclusion

The findings of the current study suggest that inspiratory muscle training with 40% of MIP for 8 weeks improved inspiratory muscle strength and chest expansion in subjects with respiratory muscle weakness. The MIP training program may be useful for improvement of chest expansion in subjects, who have an inspiratory muscle weakness.

Acknowledgements

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References

1. Ray AD, Udhoji S, Mashtare TL, Fisher NM. A combined inspiratory and expiratory muscle training program improves respiratory muscle strength and fatigue in multiple sclerosis. Arch Phys Med Rehabil 2013; 94: 1964-70.

2. de Medeiros AIC, Fuzari HKB, Rattesa C, Brandao DC, de Melo Marinho PE. Inspiratory muscle training improves respiratory muscle strength, functional capacity and quality of life in patients with chronic kidney disease: a systematic review. J Physiother 2017; 63: 76-83.
3. Neto MG, Martinez BP, Conceicao CS, Silva PE, Carvalho VO. Combined Exercise and Inspiratory Muscle Training in Patients With Heart Failure: A Systematic Review And Meta-Analysis. J Cardiopulm Rehabil Prev 2016; 36: 395-401.
4. Montemezzo D, Fregonezi GA, Pereira DA, Britto RR, Reid WD. Influence of inspiratory muscle weakness on inspiratory muscle training responses in chronic heart failure patients: a systematic review and meta-analysis. Arch Phys Med Rehabil 2014; 95: 1398-407.
5. Geddes EL, O'Brien K, Reid WD, Brooks D, Crowe J. Inspiratory muscle training in adults with chronic obstructive pulmonary disease: an update of a systematic review. Respir Med 2008; 102: 1715-29.
6. Kim CB, Yang JM, Choi JD. The effects of chest expansion resistance exercise on chest expansion and maximal respiratory pressure in elderly with inspiratory muscle weakness. J Phys Ther Sci 2015; 27: 1121-4.
7. Costa D, Goncalves HA, Lima LP, Ike D, Cancelliero KM, Montebelo MI. New reference values for maximal respiratory pressures in the Brazilian population. J Bras Pneumol 2010; 36: 306-12.
8. Lanza Fde C, de Camargo AA, Archija LR, Selman JP, Malaguti C, Dal Corso S. Chest wall mobility is related to respiratory muscle strength and lung volumes in healthy subjects. Respir Care 2013; 58: 2107-12.
9. Lutfi MF. The physiological basis and clinical significance of lung volume measurements. Multidiscip Respir Med 2017; 12: 3.
10. Sclauser Pessoa IM, Franco Parreira V, Fregonezi GA, Sheel AW, Chung F, Reid WD. Reference values for maximal inspiratory pressure: a systematic review. Can Respir J 2014; 21: 43-50.
11. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of spirometry. Eur Respir J 2005; 26: 319-38.
12. Adachi D, Yamada M, Nishiguchi S, Fukutani N, Hotta T, Tashiro Y, et al. Age-related decline in chest wall mobility: a cross-sectional study among community-dwelling elderly women. J Am Osteopath Assoc 2015; 115: 384-9.
13. Klefbeck B, Hamrah Nedjad J. Effect of inspiratory muscle training in patients with multiple sclerosis. Arch Phys Med Rehabil 2003; 84: 994-9.
14. Enright SJ, Unnithan VB, Heward C, Withnall L, Davies DH. Effect of high-intensity inspiratory muscle training on lung volumes, diaphragm thickness, and exercise capacity in subjects who are healthy. Phys Ther 2006; 86: 345-54.
15. Lin SJ, McElfresh J, Hall B, Bloom R, Farrell K. Inspiratory muscle training in patients with heart failure: a systematic review. Cardiopulm Phys Ther J 2012; 23: 29-36.