Efficacy of Inspiratory Muscle Training on Ventilatory Functions in Postmenopausal Asthmatic Women

Soheir Mahmoud Ali El-Kosery[*1], Khadyga Said Abd El-Aziz[1], Nagwa Mohamed Badr[2], Adel Farouk El- Begawy[3] and Randa Osama Mohamed[1]

[1]Department of Physical Therapy for Gynecology and Obstetrics, Faculty of Physical Therapy, Cairo University. Cairo, Egypt
[2]Department of Physical Therapy for Cardiovascular/ Respiratory Disorders and Geriatrics, Faculty of Physical Therapy, Cairo University, Cairo, Egypt
[3]Department of Gynecology and Obstetrics, Faculty of Medicine, Cairo University, Cairo, Egypt
soheir_1212@hotmail.com [*]

Abstract: This study was conducted to determine the effect of inspiratory muscles training in improving ventilatory functions in postmenopausal asthmatic women. Fourty postmenopausal women, complaining from bronchial asthma, one year ago, were participated in this study. They were divided randomly into two equal groups (A and B).Both groups received traditional medical treatment which was consisted of theophyline, salbutamol sulphate(bronchodilator), dexamethasone, carbocisteine (muco-regulator) & antibiotic for six weeks. In addition to traditional medical treatment, Group “A” received the inspiratory muscles training by using inspiratory muscle trainer. Assessment was performed by measuring weight and height then the body mass index was calculated for each woman in both groups (A&B) before treatment. Also, Electronic Spirometer was used to measure ventilatory functions (Forced Vital Capacity, Forced Expiratory Volume, Forced Vital Capacity /Forced Expiratory Volume and Maximum Voluntary Ventilation) before and after 6 weeks of treatment. Results showed a statistically highly significant improvement (P<0.001) in all ventilatory functions in group (A) than group (B) after end of treatment. So, it could be concluded that inspiratory muscle training with traditional medical treatment were more effective than traditional medical treatment only for these cases as it was effective, safe, easy to perform and led to reducing symptoms of asthma.
[Soheir Mahmoud Ali El-Kosery, Khadyga Said Abd El-Aziz, Nagwa Mohamed Badr, Adel Farouk El- Begawy and Randa Osama Mohamed. **Efficacy of Inspiratory Muscle Training on Ventilatory Functions in Postmenopausal Asthmatic Women**. Journal of American Science 2011;7(2):46-53]. (ISSN: 1545-1003). http://www.americanscience.org.

Key words: Inspiratory Muscle Trainer - Ventilatory Functions - Postmenopausal Asthmatic women.

1. Introduction:

Bronchial asthma is a major health problem throughout the world which reached the epidemic proportions (Kellett and Mullan, 2002) as its prevalence has increased over the last decades (Aly and Essa, 2006). Bronchial asthma is defined as a complex respiratory disease characterized by airways inflammation and hyperresponsiveness of bronchial smooth muscles leading to reversible bronchospasm (Bellia and Augugliaro, 2007). Bronchial asthma leads to impairment of ventilatory function that results in deterioration in functional capacity and quality of life and this impairment is influenced by age, duration and severity of the disease (Cibella et al., 2002). Menopause is associated with decreased lung function and increased respiratory symptoms (Real et al., 2008).The female hormone estrogen is an important factor in the regulation of airway function and inflammation, and sex differences in the prevalence of asthma (Matsubara et al., 2008). Bronchial asthma that begins around the time of menopause is frequently characterized by marked clinical severity and poor response to treatment (Grady, 2006). The airway inflammation present in women with menopausal asthma is poorly responsive to anti-inflammatory treatment with corticosteroids and predisposes to frequent severe exacerbations. Airway inflammation should be monitored in women with menopausal asthma (Balzano et al., 2007).Long-term use of inhaled corticosteroids is associated with significant bone loss in asthmatic women and is especially related to the duration of therapy (Kemp et al., 2010). Therefore, it is necessary to give prophylactic treatment to those who are likely to develop osteoporosis from inhaled corticosteroid treatment (Sivri and Coplu, 2001).In moderate to severe chronic obstructive pulmonary disease there is a generalized loss of muscle bulk including the respiratory muscles. Similar loss of respiratory muscle strength can occur particularly in more severe asthma due to the effects of steroid therapy (Ram et al., 2003).Asthmatic patients suffer from increased airway resistance as well as air trapping and lung hyperinflation which lead to changes in the thoraco-abdominal mechanics and inspiratory muscles impairment. It was found that the use of inspiratory muscles training as a complement to pharmacological treatment provided clinical benefits to asthmatic patients (Veruska et al., 2008). Inspiratory muscle training has been used as an adjunct treatment for various chest diseases. So, It is very important to study the effect of inspiratory muscles training to know its effect on postmenopausal asthma to improve the inspiratory muscles endurance and ventilatory functions as there is no previous study assessed the effect of inspiratory muscles training after menopause. This study was conducted to determine the effectiveness of inspiratory muscles training in improving ventilatory functions in postmenopausal asthmatic women.

2. Subjects, Materials and Methods

Subjects:

Forty postmenopausal women, complaining of bronchial asthma, one year ago were participated in this study. They were selected from Abbasia Chest Hospital. They were divided randomly into two equal groups (A and B).Group A (Study group) consisted of twenty patients. They received the inspiratory muscles training in addition to traditional medical treatment. Group B (Control group) consisted of twenty patients. They received traditional medical treatment only. Informed consent form was signed by each patient before starting this study. Their age ranged from 50 – 60 years old .All patients were non-smokers, had no cardiac ,chest diseases, diabetes, hypertension and did not receive hormonal replacement therapy. Their Body Mass Index didn't exceed 30 kg/m^2 to exclude obese women from the study.

2) Material

(A)Evaluative instruments

1-Electronic Spirometer

It was used for ventilatory functions measurements which are:-

(Forced vital capacity) is one of the most useful tests to assess the overall ability to move air in and out of the lungs (ventilation). This is the maximum amount of air that can be forcefully and rapidly exhaled after a deep breath (maximal inspiration). (Forced expiratory volume) is the volume of air forcibly exhaled in one second during the FVC test. It decreased in obstructive lung disease as bronchial asthma.

(Maximum voluntary ventilation) is the maximum air, which can be expired in a minute by deepest and fastest breathing. It typically decreased in subjects with moderate or severe obstructive disease.

2-Weight and height scale:

It was used for measuring the weight and height of each patient to calculate the body mass index.

(B)Treatment instruments:

Inspiratory muscles trainer

It is an inspiratory muscle trainer that helps to increase respiratory muscles strength and endurance through conditioning. This is similar to muscle conditioning used in weight training. It works by placing a specific constant resistance on respiratory muscles regardless of how quickly or slowly the patient breathes. This resistance is provided by a spring loaded valve which exercises the respiratory muscles when inhalation occurred (Lima et al.,2008). The goal is that the patient should be able to inhale with enough force to open the valve. He will know that he is training correctly and using the proper force when the air is heard flowing through the device. This may be difficult to do at first but will be easier as he progresses (Deane,2005).. Inspiratory Muscle Trainer device consisted of a portable handheld device through which patients would inspire only when they overcome the threshold resistance of the device. Inspiratory muscle training appeared to consistently improve ventilatory muscle strength, endurance, and dyspnea (Deturk and Cahalin, 2004).

3) Methods:

(A)Methods for Evaluation:

These methods for patient's evaluation were preformed for both groups A &B. Each patient participated in this study was primarily diagnosed and referred by physician. Before engagement into the study, a detailed medical history was taken and recorded including name, age, address, occupation, parity, any chest diseases before menopause. As well as, the vital signs were measured. Then, weight and height were measured for each patient in both groups before starting the study and body mass index was calculated to exclude obese women.

Ventilatory Function Test, was performed before and after the end of treatment period (6 weeks).In which the patient was instructed to assume the erect standing position carrying the breathing tube that was connected to the spirometry and in its other end there was a disposable mouthpiece to prevent infection. The patient's age, weight and height were introduced into the screen of the apparatus. Then, each patient was instructed to perform the test while wearing nasal clip (Kevin, 2006).These procedures were repeated 3-5 times with rest in between and the maximum value was recorded for evaluation of ventilatory functions (Forced Vital Capacity test, Forced Expiatory Volume, Forced Expiatory Volume / Forced Vital Capacity and Maximum Voluntary Ventilation).

(B)Treatment procedure:

Both groups(A&B) received traditional medical treatment which was consisted of theophyline, salbutamol sulphate (bronchodilator), dexamethasone, carbocisteine (muco-regulator) & antibiotic for six weeks. In addition to traditional medical treatment, Group "A" received the inspiratory muscles training by using inspiratory muscle trainer.The maximum training load was set, the user identified the load at which she could successfully execute ten breaths at maximum resistance depending on the patient's rate of perceived exertion (Alison, 2005). It is recommended to start training with a load equal to 30% of the patient's maximum inspiratory effort. This individualized load increased progressively as the inspiratory muscles became more stronger. The recommended pressure load determined by the 30% maximum 10-repetition method by using the device.

Duration:

Each session was divided into six work sets, separated by rest intervals lasting for two minutes. Each set consisted of five breathing in and out and rest for three seconds this repeated for three minutes.

Frequency:

Three sessions/week for six weeks.

Precautions during inspiratory muscles training:

***Breath in should be deep and forced with a long and slow expiration.

*If patient started to feel headache, she will ask to slow down pause before the next breath.

*Patient was instructed not to eat at least 2 hours before training.

*Patient was instructed to keep her mouth tight around the mouthpiece for the total time.

*Using nasal clip to close the nose.

The patient was asked to sit in a comfortable position and put the nose clip on her nose and to breathe through the mouth only. Relax, place her lips around the mouthpiece, and inhale as deeply as she can with enough force to open the valve. Exhale through mouthpiece; continue inhaling and exhaling without removing the device from her mouth.

Data Processing (Statistical Analysis):

The collected data were statistically analyzed and interpreted using Mann-Witney U test, Friedman test, Wilcoxn Signed Ranks test and Chi square test to compare between both groups to obtain Mean, Standard deviation, Minimum as well as maximum values & Percentages. The level of significance (P value) was considered as follow: P>0.05 considered not significant, P<0.05 considered significant, P>0.01 considered highly significant.

3. Results

Forced Expiratory Volume:

In group "A", it showed a highly significant (P< 0.0001) difference between before and after treatment where the mean values were (1.38±0.16) and (1.73±0.17) respectively with mean difference equal 0.35 and percentage of improvement equal 25.36% While in group "B", there was non significant (P< 0.78) differences between before and after treatment where the mean values were (1.37±0.28) and (1.38±0.23) respectively with mean difference equal 0.005 and percentage of improvement equal 0.36%. When comparing both groups (A&B) together there was non significant (P<0.87) difference before treatment. While, there was a highly significant (P<0.0001) difference after treatment.

Table 1. Mean values of Forced Expiratory Volume before and after treatment of group (A).

Group A (Study group)	**FEV_1**	
	Before treatment	**After treatment**
Mean	**1.38**	**1.73**
±SD	**±0.16**	**±0.17**
Mean difference	**0.35**	
Percentage of improvement	**25.36 %**	
DF	**19**	
t-value	**10.97**	
P-value	**0.0001**	
S	**HS**	

*SD: standard deviation, P: probability,
S: significance, HS: highly significant,
DF: degree of freedom.

Table 2. Mean values of Forced Expiratory Volume before and after treatment of group (B).

Group B (Control group)	**FEV_1**	
	Before treatment	**After treatment**
Mean	**1.37**	**1.38**
±SD	**±0.28**	**±0.23**
Mean difference	**0.005**	
Percentage of improvement	**0.36%**	
DF	**19**	
t-value	**0.27**	
P-value	**0.78**	
S	**NS**	

*SD: standard deviation, P: probability,
S: significance, NS: non-significant,
DF: degree of freedom.

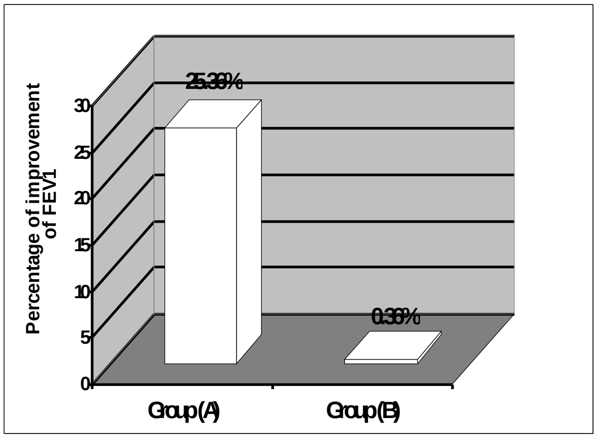

Figure 1. Total percentage of improvement in Forced Expiratory Volume from before to after treatment for both groups (A&B).

Forced Vital Capacity:

In group “A”, It showed a highly significant (P< 0.0001) difference between before and after treatment where the mean values were (2.26±0.28) and (2.57±0.28) respectively with mean difference equal 0.31 and percentage of improvement equal 13.71%. While in group “B”, there was non significant (P< 0.75). differences between before and after treatment where the mean values were (2.2±0.33) and (2.21±0.34) respectively with mean difference equal 0.006 and percentage of improvement equal 0.27 % .When comparing both groups (A&B) together there was non significant (P< 0.57) difference before treatment. While, there was a highly significant (P< 0.001) difference after treatment.

Table 3. Mean values of Forced Vital Capacity before and after treatment of group (A).

Group A (Study group)	FVC	
	Before treatment	After treatment
Mean	2.26	2.57
±SD	±0.28	±0.28
Mean difference	0.31	
Percentage of improvement	13.71 %	
DF	19	
t-value	9.9	
P-value	0.0001	
S	HS	

*SD: standard deviation, P: probability,
S: significance, HS: highly significant,
DF: degree of freedom.

Table 4. Mean values of Forced Vital Capacity before and after treatment of group (B).

Group B (Control group)	FVC	
	Before treatment	After treatment
Mean	2.2	2.21
±SD	±0.33	±0.34
Mean difference	0.006	
Percentage of improvement	0.27%	
DF	19	
t-value	0.31	
P-value	0.75	
S	NS	

*SD: standard deviation, P: probability,
S: significance, NS: non-significant,
DF: degree of freedom.

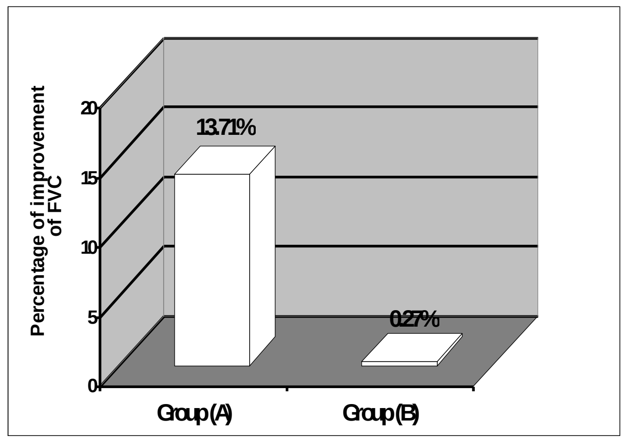

Figure 2. Total percentage of improvement in Forced Vital Capacity from before to after treatment for both groups (A&B)

Forced Expiratory Volume / Forced Vital Capacity:

In group “A”, it showed a highly significant (P<0.0001) difference between before and after treatment where the mean values were (61.57±6.19) and (67.73±5.49) respectively with mean difference equal 6.16 and percentage of improvement equal 10.0%. While in group “B”, there was non significant (P<0.69) difference between before and after treatment where the mean values were (62.18±6.89) and (62.61±6.81) respectively with mean difference equal 0.42 and percentage of improvement equal 0.67%. When comparing both groups (A&B) together there was non significant (P<0.76) difference before treatment While, there was a highly significant (P< 0.01) difference after treatment

Table 5. Mean values of Forced Expiratory Volume / Forced Vital Capacity before and after treatment of group (A).

Group A (Study group)	FEV_1/FVC	
	Before treatment	After treatment
Mean	61.57	67.73
±SD	±6.19	±5.49
Mean difference	6.16	
Percentage of improvement	10.0 %	
DF	19	
t-value	4.42	
P-value	0.0001	
S	HS	

*SD: standard deviation, P: probability,
S: significance, HS: highly significant,
DF: degree of freedom.

Table 6. Mean values of Forced Expiratory Volume / Forced Vital Capacity before and after treatment of group (B).

Group B (Control group)	FEV_1/FVC	
	Before treatment	After treatment
Mean	62.18	62.61
±SD	±6.89	±6.81
Mean difference	0.42	
Percentage of improvement	0.67%	
DF	19	
t-value	0.39	
P-value	0.69	
S	NS	

*SD: standard deviation, P: probability,
S: significance, NS: non-significant,
DF: degree of freedom.

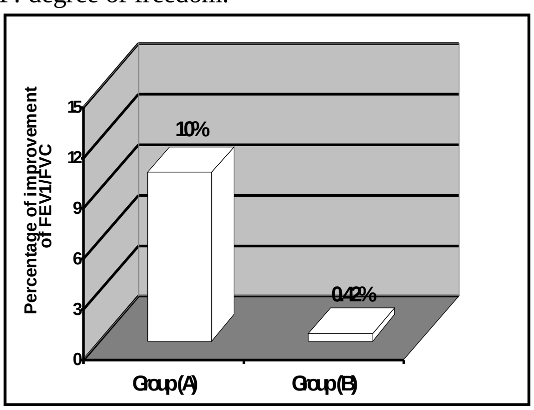

Figure 3. Total percentage of improvement in Forced Expiratory Volume / Forced Vital Capacity from before to after treatment for both groups (A&B).

Maximum Voluntary Ventilation:

In group "A", It showed a highly significant (P< 0.0001) difference between before and after treatment where the mean values were (55.5±6.53) and (69.56±6.8) respectively with mean difference equal 14.04 and percentage of improvement equal 25.29 %. While in group "B", there was non significant (P< 0.62) difference between before and after treatment where the mean values were (54.84±11.09) and (55.24±9.39) respectively with mean difference equal 0.4 and percentage of improvement equal 0.72 %. When comparing both groups (A&B) together there was non significant (P< 0.82) difference before treatment. While, there was a highly significant (P< 0.0001) difference after treatment.

Table 7. Mean values of Maximum Voluntary Ventilation before and after treatment of group (A).

Group A (Study group)	MVV	
	Before treatment	After treatment
Mean	55.5	69.56
±SD	±6.53	±6.8
Mean difference	14.04	
Percentage of improvement	25.29 %	
DF	19	
t-value	10.97	
P-value	0.0001	
S	HS	

*SD: standard deviation, P: probability,
S: significance, HS: highly significant,
DF: degree of freedom.

Table 8. Mean values of Maximum Voluntary Ventilation before and after treatment of group (B).

Group B (Control group)	MVV	
	Before treatment	After treatment
Mean	54.84	55.24
±SD	±11.09	±9.39
Mean difference	0.4	
Percentage of improvement	0.72%	
DF	19	
t-value	0.49	
P-value	0.62	
S	NS	

*SD: standard deviation, P: probability,
S: significance, NS: non-significant,
DF: degree of freedom.

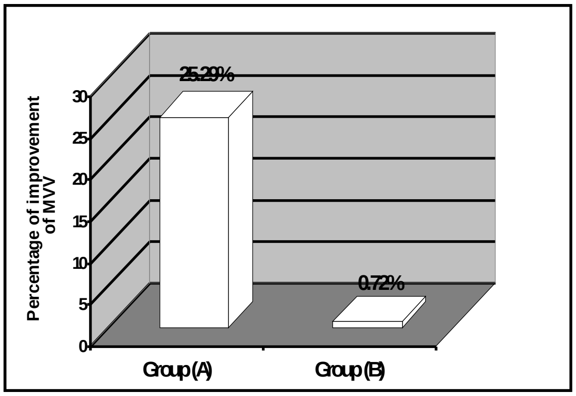

Figure 4. Total percentage of improvement in Maximum Voluntary Ventilation from before to after treatment for both groups (A&B).

4. Discussion:

Severe bronchial asthma is more predominant in women. Asthma in women is associated with excess mortality risk and women with asthma were found to visit the emergency department for asthma more frequently than men. Subsequent hospitalization rates for asthma reflect the difference in asthma prevalence and severity as observed between men and women (Melgert et al., 2007). Asthma that begins around the time of menopause is frequently characterized by marked clinical severity and poor response to treatment (Carey et al., 2007). The airway inflammation presented in women with menopausal asthma was poorly responsive to anti-inflammatory treatment with corticosteroids and predisposed to frequent severe exacerbations. Airway inflammation should be monitored in women with menopausal asthma (Balzano et al., 2007). Causes of asthma at menopause are not clear until now. It was suggested that declining estrogen levels increased insulin resistance, which in turn increased risk of lung inflammation (Denoon, 2007).In patients with pulmonary diseases, several studies have shown that inspiratory muscle training improves inspiratory muscle strength as well as exercise endurance. Also, it may prevent or delay the onset of ventilatory muscle fatigue and failure, and has been shown to decrease dyspnea over time (Jones et al., 2003). Some studies have shown that the respiratory muscles can be trained if an adequate training stimulus is applied, and that exercise performance and dyspnea may improve as result of such training by resistive breathing or threshold loading (Thomas, 2000). (Koessler et al., 2001) found an increase in the strength of inspiratory muscles, increase VC and MVV in patients with neuromuscular disorders and obstructive lung disease after program of inspiratory muscle training. Another improvement in MVV had been reported by (Winker et al., 2000) after 9 months of inspiratory muscle training. The thorax is a complex assembly of muscles and bony structures. Like other skeletal muscles, the rational for inspiratory muscle training is that increasing the strength or endurance of the respiratory muscles can improve clinical outcomes, reduce the severity of dyspnea) and enhance the ability of individuals to perform daily activities (Murray and Mahler,2009). This study was designed to determine the effect of inspiratory muscles training in improving ventilatory functions in postmenopausal asthma. Fourty postmenopausal asthmatic women were selected from Abbasia Chest Hospital & they were divided randomly into two groups (A and B) equal in numbers with non significant differences ($p > 0.05$) in age, weight, height and body mass index. Assessment of FEV_1, FVC, FEV_1/FVC and MVV were performed to each woman before starting the study and after 6 weeks of treatment. The current study showed a statistacally significant improvement after treatment (FEV_1,FVC,FEV_1/FVC and MVV) in group "A".The ventilatory muscle training in individuals with respiratory disease (asthma) leads to increasing the strength and/or endurance of the respiratory muscles as well as reducing the severity of dyspnea and improve exercise capacity which was supported by Mahler, 2000. The results of this study showed that inspiratory muscles training not only significantly increased inspiratory muscle strength and endurance but also improved ventilatory functions. In addition, a significant clinical decrease in dyspnea sensation at rest and during exercise was observed after its usage and this was supported by the work of Weiner et al., 2004. These results were supported with the results obtained by Keene (2007) who stated that Inspiratory Muscle Training offered a basis for pulmonary rehabilitation to patients with obstructive lung diseases as they were able to increase their Inspiratory muscle strength. With the strengthening of these muscles. There was increasing of the FVC of a patient, also their overall lung volume increased. This produced a direct decrease in their airway resistance and presumably a decrease in their levels of dyspnea. In conclusion, inspiratory muscles training are a proven way to increase an asthma patient's FVC. This aided in reducing their levels of dyspnea and in turn can be used as an alternative physiologic form of therapy to reduce their intake of systemic corticosteroids and inhaled beta -2 agonists. Also, its effects were noted in improving inspiratory muscle strength and endurance, improved functional exercise capacity, and decreased dyspnea, during exercise and at rest. As well as, it was suggested that inspiratory muscle training is a very essential in pulmonary rehabilitation programs (Hanneke et al., 2001). The results of the basic training program parallel other studies in which significantly increased inspiratory muscle performance was associated with improved exercise tolerance, decreased dyspnea and improvement of ventilatory functions. The training response of respiratory muscles is similar to that of skeletal muscles as it produced a hypertrophy of muscle fibers & increased the vascularity of muscle fibers (number of capillaries in each fiber) (Minoguchi and Shibuya, 2002). Finally, from statistical point of view, it could be concluded that inspiratory muscles training with medical treatment appeared to be an effective, safe, easy to perform and improve quality of life.

Corresponding author
Soheir Mahmoud Ali El-Kosery
Department of Physical Therapy for Gynecology and Obstetrics, Faculty of Physical Therapy, Cairo University. Cairo, Egypt
soheir_1212@hotmail.com

5. References:

1. Alison M.: Inspiratory muscle training for managing breathlessness. Nursing in practice Jan/Feb; 60-64, 2005.
2. Aly, F. and Essa, M.: Efficacy of breathing retraining using modified incentive spirometeric biofeedback system on ventilatory function in moderate versus severe asthmatic children. Bull. Fac. Ph. Th. Cairo Univ., 11, (1):65-73, 2006.
3. Balzano, G.; Fuschillo, S.; De Angelis, E.; Gaudiosi, C.; Mancini, A. and Caputi, M.: Persistent airway inflammation and high exacerbation rate in asthma that starts at menopause. Monaldi Arch. Chest Dis., 67(3):135-141, 2007.
4. Bellia, V. and Augugliaro, G: Asthma and menopause.Monaldi Arch. Chest Dis., 67(3):125-127, 2007.
5. Carey, M.; Card, J.; Voltz, J.; Arbes, S.; Germolec, D.; Korach, K. and Zeldin, D.: It's all about sex: male-female differences in lung development and disease. Trends Endocrinol. Metab., 18(8):308-313, 2007.
6. Cibella, F.; Giuseppina, C.; Vincenzo, B.; Salatore, B.; Silvestre, D.; Daniela, G. and Giovanni, B.: Lung function decline in bronchial asthma.J.American College of Chest Physician, 122:1944-1984, 2002.
7. Deane, H.: A manual for Patients and their families. Available from URL: www.sierrabiotech.com/bt_copd_imt.htm., 2005.
8. Denoon D,: Menopause Ups lean Women's Asthma Risk. WebMD Health News 2007.
9. DeTurk, W. and Cahalin, L.: Cardiovascular and pulmonary physical therapy: An evidence-based approach. McGraw-Hill, pp.524, 2004.
10. Grady, D.: Management of menopausal symptoms. NEJM (The New England Journal of Medicine), 355(22):2338-2347, 2006.
11. Hanneke, W.; Brenda, P. and Marten: Determinants of different dimensions of disease severity in asthma and COPD. J American College of chest physicians, 119: 1034-1042, 2001.
12. Jones, A.; Dean, E. and Chow, C.: Comparison of the oxygen cost of breathing exercise and spontaneous breathing in patients with stable chronic obstructive pulmonary disease. Phys Ther., 83 (5): 424-431, 2003.
13. Keene, S.: Studying the effects of inspiratory muscle training in patients with obstructive lung diseases. The Internet Journal of Pulmonary Medicine, 7(2):1531-2984, 2007.
14. Kellett, C. and Mullan, J.: Breathing control techniques in the management of asthma. Physiotherapy, 88 (12): 751-758, 2002.
15. Kemp,L.;Haughney,J.;Barnes,N.;Sims,E.;Ziegen weidt,J.;Hillyer,E.;Lee,A.;Chisholm,A. and Price, D.: Cost-effectivenesss analysis of corticosteroid inhaler devices in primary care asthma management: A real world observational study. ClinicoEconomics and Outcomes Research, 2:75-85, 2010.
16. Kevin, M. : Pulmonary function testing. Am. J. Respir. Crit. Care Med., 160:1700-1705, 2006.
17. Koessler, W.; Wanke, T.; Winkler, G.; Nader, A.; Toifl, K.; Kurz, H. and Zwick, H.: Two years experience with inspiratory muscle training in patient with neuromuscular disorders. Chest, 120:765-769, 2001.
18. Lima, E.; Lima, W.; Nobre, A.; Santos, A.; Brito, l. and Costa, M.: Inspiratory muscle training and respiratory exercises in children with asthma. J. Bras. Pneumol., 34(8):1801-1810, 2008.
19. Mahler, D.: Ventilatory muscle training. In: Hodgkin J.; Celli B.and Connors G., editors. Pulmonary rehabilitation. Guidelines to success. Lippincott Williams& Wilkins, 3rd ed., Ch (11), pp.165-172, 2000.
20. Matsubara, S.; Swasey, C.; Loader,J.; Dakhama, A.; Joetham, A.; Ohnishi,H.; Balhorn,A.; Miyahara,N.;Takeda,K. and Gelfand,E.: Estrogen determines sex differences in airway responsiveness after allergen exposure. American Journal of Respiratory Cell and Molecular Biology, 38:501-508, 2008.
21. Melgert, B.; Ray, A.; Hylkema, M.; Timens, W. and Postma, D.: Are there reasons why adult

asthma is more common in females?. Current Allergy and Asthma reports, 7(2):143-150, 2007.
22. Minoguchi, H. and Shibuya, M.: Cross-over comparison between respiratory muscle stretch gymmstics and inspiratory muscle training. Int. Med., 44(10):805-812, 2002.
23. Murray, J. and Mahler, D.: Inspiratory muscle training. In: Hodgkin J.; Celli B.and Connors G., editors. Pulmonary rehabilitation.Guidlines to success. Mosby, Elsevier, 4th ed., Ch (11) pp.143-153, 2009.
24. Ram, F.; Wellington, S.and Barnes, N.: Inspiratory muscle training for asthma. Cochrane Database of Systematic Reviews, issue 4, CD003792, 2003.
25. Real, F.; Svanes,C.; Omenaas, E.; Antò,J.; Plana, E.; Jarvis, D. ; Janson, C.; Neukirch, F.; Zemp,E.; Dratva, J.;Wjst, M.; Svanes,K.; Leynaert, B. and Sunyer, J.: Lung function, respiratory symptoms and the menopausal transition. J. Allergy Clin, Immunol. , 121(1):72-80, 2008.
26. Sivri, A. and Coplu, L.: Effect of the long –term use of inhaled corticosteroids on bone mineral density in asthmatic women. Journal compilation Asian pacific society of respirology, 6 (2): 131-134, 2001.
27. Thomas, A.: Respiratory muscle endurance training in chronic obstructive pulmonary disease impact on exercise capacity, dyspnea, and quality of life. Am. J. Respire. Crit. Care Med., 162:1709-1714, 2000.
28. Timothy, J. and Irene, P.: An approach to interpreting spirometry. American family physician, 69(5): 1107-1108, 2004.
29. Veruska, E.; Leite, W.; Nobre, A.; Miranda, A.; Maria, L. and Rosario, M.: Inspiratory muscle training and respiratory exercises in children with asthma. Journal Brasileiro De Pneumologia, 34(8):2008.
30. Weiner P.; Magadle, M.; Beckerman, M.; Weiner and Berar-Yanay, N.: Maintenance of inspiratory muscle training in COPD patients: one-year follow-up. Eur. Respir. J., 23:361-65, 2004.
31. Winker, G.; Zifko, U.; Nader, A.; Frank, W.; Zwich, H.; Toifl, K. and Wanke, T.: Dose-dependant effects of inspiratory muscle training in neuromuscular disorders. Muscle and Nerve, 23: 1257-1260, 2000.

12/14/2010