

Aerobic Exercise Training and Incentive Spirometry Can Control Age-Related Respiratory Muscles Performance Changes in Elderly

Shehab Mahmoud Abd El- Kader¹, Eman Mohamed Salah El-Den Ashmawy²

ABSTRACT

As aging occurs, the respiratory system undergoes a measurable decline in physiological functions. The aim of this study was to determine the effect of walking exercise and incentive spirometry in controlling age related respiratory muscles function changes in elderly. Forty elderly subjects of both sexes their age ranged from 65 to 74 years and included into two equal groups; group (A) received walking exercise and incentive spirometry three times a week for 3 months, where group (B) received no physical therapy intervention. The mean values of VC, FEV₁, MVV, P_{lmax}, P_Emax and P_{END} were significantly increase in group (A), while changes in group (B) were not significant. Also; there were significant differences between both groups at the end of the study. Application of breathing exercise with an incentive spirometer in addition to walking exercise can control age related respiratory muscles function changes in elderly.

Key words: Aerobic exercise, incentive spirometry, aging, respiratory muscles

Aerobik Egzesiz ve Incentive Spirometri Yaşlı Hastalarda Yaş ile İlişkili Solunum Kas Performansını Kontrol Edebilir

ÖZET

Yaşlanma süreci boyunca solunum sistemi fizyolojik fonksiyonlarında ölçülebilir bir azalma gözlenir. Bu çalışmanın amacı yaşlılarda yürüme egzersizi ve incentive spirometre nin yaşla ilişkili solunum kas fonksiyonları değişikliği üzerine olan etkisinin incelenmesiydi. Yaşları 65 ile 74 arasında olan her iki cinsten 40 yaşlı denek iki eş gruba ayrıldı. Grup (A) 3 ay süresince haftada üç kez yürüme egzersizi ve incentive spirometry yaptırıldı. Grup (B) ye fizik tedavi girişimi yapılmadı. VC, FEV₁, MVV, P_{lmax}, P_Emax ve P_{END} için ortalama değerler grup (A) da anlamlı derecede daha yüksekti, grup (B) deki değişiklikler ise anlamlı değildi. Ayrıca her iki grup arasında çalışma sonucunda değerlerde anlamlı farklılık mevcuttu. Incentiv spirometre ile yaptırılan solunum egzersizi yürüme egzersizi ile birleştirildiğinde yaşlılarda yaş ile ilişkili olarak gelişen solunum kas fonksiyonu değişikliklerini kontrol edebilir.

Anahtar kelimeler: Aerobik egzersiz, incentiv spirometri, yaşlanma, solunum kasları

¹ Cairo University, Department of Physical Therapy for Cardiopulmonary Disorders and Geriatrics Faculty of Physical Therapy, Egypt. ² King Abdulaziz University, Faculty of Applied Medical Sciences, Department of Physical Therapy, Jeddah, Saudi Arabia.

Correspondence: Shehab Mahmoud Abd El- Kader
Faculty of Applied Medical Sciences, Department of Physical Therapy, King Abdulaziz University, P.O. Box 80324, Jeddah, 21589, Saudi Arabia.
Cell phone: +966-569849276
E-mail: profshehab@live.com

INTRODUCTION

Normal aging of the respiratory system is associated with a decrease in static elastic recoil of the lung, in respiratory muscle performance, and in compliance of the chest wall and respiratory system, resulting in increased work of breathing compared with younger subjects and a diminished respiratory reserve in cases of acute illness, such as heart failure, infection, or airway obstruction. In spite of these changes, the respiratory system remains capable of maintaining adequate gas exchange at rest and during exertion during the entire lifespan, with only a slight decrease in P_{aO_2} and no significant change in P_{aCO_2} (1). Age-related structural lung changes include decreased elastic recoil of the lung, increased chest wall rigidity and as a result decreased force-generating capacity of the respiratory muscles. These changes lead to an increase in functional residual capacity and residual volume, decrease in the inspiratory reserve volume, the expiratory reserve volume, the vital capacity and increase in residual volume (2). There is a gradual age related decline in the pulmonary function beginning at about age forty. The elastic recoil of the lungs decreases owing to changes in elastin and collagen. The lung weight is decreased by approximately one fifth, the bronchi harden, and the bronchial epithelium and mucous glands degenerate. The alveolar ducts and bronchioles enlarge, with an accompanying decrease in the depth of the alveolar sacs. The alveoli decrease in number, and the cilia become less active, also, with inhalation the lung bases of the elderly do not inflate well and secretions are not expelled (3). There is a greater resistance to airflow due to narrowing of the bronchioles. The vital capacity (VC) forced expiratory volume in the first second (FEV1), maximum voluntary ventilation (MVV) and peak expiratory flow (PEF) decrease while the residual volume increases due to loss of elastic recoil, reduction in elasticity, air trapping, weakness of respiratory muscles, costal cartilage calcifies and ribs become less mobile (3,4).

Incentive spirometry is widely used clinically as an adjunct to chest physiotherapy that provides the patient with visual feedback of the volume of air inspired during a deep breath. It provides low-level resistive training while minimizing the potential of fatigue to the diaphragm. It has been used to enhance lung expansion and inspiratory muscle strength (5). Pulmonary rehabilitation program incorporating aerobic exercise training improves respiratory muscle function (Strength and endurance), pulmonary function test and six minute walking test (6).

The aim of this study was to investigate the efficacy of aerobic exercise training (treadmill walking exercise) and inspiratory muscle training (incentive spirometry) in controlling pulmonary age related changes in healthy elders.

MATERIALS AND METHODS

Subject

Forty healthy elderly subjects of both sexes (20 males and 20 females), their age ranged from 65-72 years with ideal body weight, free from diabetes, cardiovascular and chest disease. Participants were divided into two equal groups; group (A) received walking exercise and incentive spirometry three times a week for 3 months, where group (B) received no physical therapy intervention. Subjects were presented with a consent form before screening. This study was approved by the Scientific Research Ethical Committee, Faculty of Applied Sciences, King Abdulaziz University. Informed consent was obtained from all participants. All participants were free to withdraw from the study at any time. If any adverse effects had occurred, the experiment would have been stopped, with this being announced to the Human Subjects Review Board.

Methods

Ventilatory Function Test and Arterial Oxygen Saturation Measurements: Spirometer (Schiller-Spirovit Sp-10, Swizerland) was used to measure the ventilatory function test includes VC, FEV1 and MVV.

Respiratory muscle strength: A portable mouth pressure gauge (Spirovis, Cosmed, Italy) was used to measure maximal inspiratory pressure (P_Imax) and maximal expiratory pressure (P_Emax) generated at the mouth. The Spirovis consists of an occluded airway, which contains a 2 mm diameter leak to prevent artificially elevated pressures being developed by the musculature of the mouth while the glottis is closed. P_Imax was performed from residual volume and P_Emax was performed from total lung capacity (7). Participants were in a seated position and were required to hold the sides of the mouth during P_Emax assessment to prevent air leaking out the side of the mouthpiece. Participants were required to breathe through the mouthpiece, attempting to "inhale/exhale the air as fast and hard as possible" for about 4 s. The maximum pressure maintained for 1 s was recorded. All participants performed a minimum of three trials until

Table 1. Demographic data for participants in the two groups

Group	Age (year)	Weight (kg)	Height(cm)	BMI (kg/m ²)
Group (A)	67.27 ± 5.05	74.83 ± 7.69	167.62 ± 6.52	26.53 ± 4.23
Group (B)	69.18 ± 4.13	75.93 ± 8.03	170.31 ± 5.41	25.98 ± 4.76

three technically correct efforts were made. Sixty seconds rest was permitted to ensure adequate recovery between trials. The highest value within $\pm 5\%$ variability was recorded. The reliability of this procedure has been published previously with healthy subjects (8).

Inspiratory muscle endurance: The Powerlung™ RM training device (Powerlung, USA) was used to assess inspiratory muscle endurance through a 2 min incremental threshold loading (ITL) test (9). The reliability and validity of this test has been documented, with strong test-retest reliability of 0.90 for maximal pressure maintained for a complete stage (10). After inspiring against a resistance for 2 min, the participant underwent 2 min rest involving normal breathing and the threshold pressure was then increased. This process continued until the participant could no longer overcome the threshold pressure and generate airflow, which was sufficient to open the valve. The maximum pressure sustained for a complete 2-min stage was recorded for analysis (PEND) (9).

Aerobic Exercise Training: Participants of group (A) received aerobic exercise training on treadmill (Enraf Nonium, Model display panel Standard, NR 1475.801, Holland) with an intensity of 60% of maximum heart rate,

then gradually increased until reaching 75% of maximum heart rate by the end of three months. The duration of each session was thirty minutes, included five minutes warming up, twenty minutes for active stage of training and five minutes for cooling down, the training was repeated three times per week for three months.

Breathing exercise training: Participants of group (A) received breathing exercise training with incentive spirometer (volydyne volumetric manufactured by Sherwood medical company U.S.A) which was a respiratory therapy device that provided visual feedback in term of volumetric success as a patient performs a deep breath. Application of breathing exercise training with incentive spirometer was applied for five minutes, five times a day for three months.

Statistical analysis

The results were expressed as mean \pm standard deviation for each group. The significance level was determined as $p < 0.05$. The mean values of VC, FEV1, MVV, PImax, PEmax and PEND obtained before and after three months in both groups were compared using paired "t" test. Independent "t" test was used for the comparison between the two groups

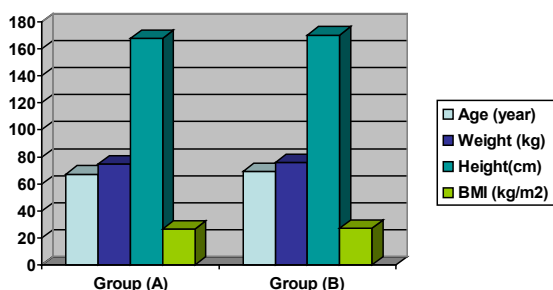
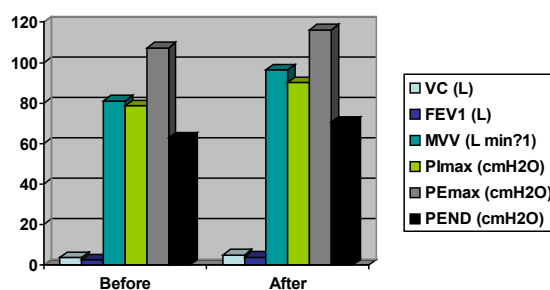
**Figure 1.** Demographic data for participants in the two groups**Figure 2.** Spirometry, inspiratory muscle endurance and respiratory muscle strength in group (A) before and after treatment.

Table 2. Spirometry, inspiratory muscle endurance and respiratory muscle strength in group (A) before and after treatment.

	Before	After	t value	p value
VC (L)	3.62±0.85	4.97±0.75	5.86	< 0.05
FEV1 (L)	2.42±0.71	3.88±0.65	4.32	< 0.05
MVV (L min ⁻¹)	81.13±11.47	96.42±9.14	8.17	< 0.05
PI _{max} (cmH ₂ O)	78.62±10.35	90.12±9.52	7.63	< 0.05
PE _{max} (cmH ₂ O)	107.34±16.91	116.27±12.33	10.91	< 0.05
PEND (cmH ₂ O)	62.78±9.13	70.54±8.26	6.85	< 0.05

C, vital capacity, FEV₁, forced expiratory volume in 1 s, MVV, maximum voluntary ventilation, PI_{max}, maximum inspiratory pressure, PE_{max}, maximum expiratory pressure, PEND, pressure for greatest completed 2 min stage of incremental inspiratory muscle endurance test

RESULTS

The two groups were considered homogeneous regarding the demographic variables (Table 1 and Figure 1). Concerning the mean values of VC, FEV₁, MVV, PI_{max}, PE_{max} and PEND were significantly increased in group (A) (Table 2, Figure 2), while changes in group (B) were not significant (Table 3, Figure 3). Also; there were significant differences between both groups at the end of the study (Table 4, Figure 4).

DISCUSSION

Individuals over 65 years of age even with a healthy life style have a decrease in several organic functions, where the lungs can lose greater than 40% of their capacity over time (11). Moreover, people become older, the respiratory muscles tend to be become weaker (12), in addition ageing is related to a significant reduction in respiratory muscle strength and endurance in males and females, so specific training programs to increase respiratory muscle strength may improve walking ability and functional performance capacity in the older popu-

lation (13,14). The results of the present study revealed that application of breathing exercise with an incentive spirometer in addition to walking exercise can control age related respiratory muscles function changes in the elderly, these results agreed with the previous studies in this area. The effects of incentive spirometry on pulmonary functions and arterial blood gases were studied in normal adults of advanced age and patients with chronic pulmonary emphysema. Both groups showed significant increases in VC, FEV₁, PEF and PaO₂ (15-17). However, application of biofeedback assisted breathing exercises for patients with cystic fibrosis resulted in a significant improvement in VC, FEV₁ and arterial oxygen saturation. These data suggest that respiratory muscle feedback assisted breathing exercise training may improve lung function in patients with cystic fibrosis (4). However, the increase in VC observed in subjects received breathing exercises might be related to the enhanced strength of the respiratory muscles and reduction of air trapping. While, the possible mechanisms to explain the improvement in FEV₁ might include increased respiratory muscle strength, increased use of

Table 3. Spirometry, inspiratory muscle endurance and respiratory muscle strength in group (A) before and after treatment.

	Before	After	t value	p value
VC (L)	3.73±0.94	3.58±0.87	0.91	>0.05
FEV ₁ (L)	2.61±0.78	2.50±0.72	0.76	>0.05
MVV (L min ⁻¹)	83.42±10.51	81.64±10.21	1.13	>0.05
PI _{max} (cmH ₂ O)	80.13±11.22	78.75±10.35	1.42	>0.05
PE _{max} (cmH ₂ O)	110.45±17.64	106.82±15.93	1.78	>0.05
PEND (cmH ₂ O)	64.37±10.92	62.15±10.14	1.57	>0.05

C, vital capacity, FEV₁, forced expiratory volume in 1 s, MVV, maximum voluntary ventilation, PI_{max}, maximum inspiratory pressure, PE_{max}, maximum expiratory pressure, PEND, pressure for greatest completed 2 min stage of incremental inspiratory muscle endurance test

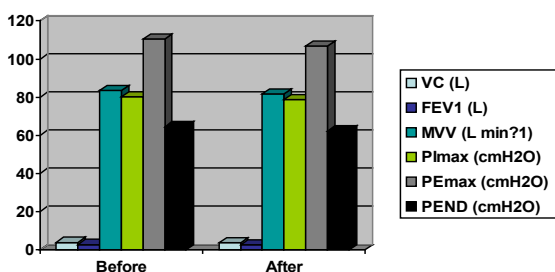


Figure 3. Spirometry, inspiratory muscle endurance and respiratory muscle strength in group (B) before and after treatment.

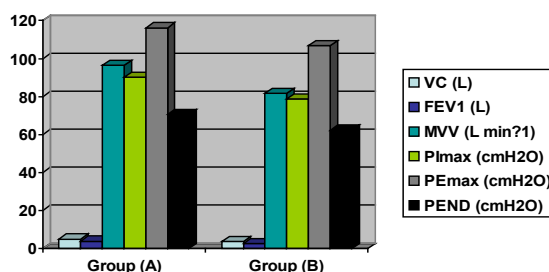


Figure 4. Spirometry, inspiratory muscle endurance and respiratory muscle strength in group (A) and group (B) after treatment.

the diaphragm in the expiratory maneuver and better coordinated use of musculature in expelling air (4, 18).

The possible explanation of the improvement in MVV following breathing exercise is increase in respiratory muscle efficiency. While, reduction in air trapping, improvement in lung compliance and reduced airway resistance are the possible effects of respiratory muscle training (19). Also, respiratory muscle training by incentive spirometer increases production of surfactant which leads to reducing surface tension, increasing lung compliance, decreasing the work of breathing and opening of collapsed alveoli to prevent atelectasis (17). Application of treadmill walking exercise three times weekly for 8 weeks resulted in increased exercise endurance, less dyspnea, improved VC, MVV and twelve minute walking test. Improvements may be due to one or more of the following factors: improved aerobic capacity, or muscle strength or both, increased motivation and improved ventilatory muscle function (6). While, after exercise training an older individual

is able to show some improvement in the pulmonary response to exercise. Most of the improved pulmonary function results from greater efficiency of ventilatory and skeletal muscle performance. This is evidenced by the decreased production of lactate and carbon dioxide when undertaking a given workload. The individual is able to work at a lower percentage of MVV and has an increased ventilatory response for given oxygen uptake and less perceived dyspnea (18, 19). Improved pulmonary function may also be attributed to the increase in thoracic mobility typically seen after exercise training. Individuals who are initially sedentary show the greatest improvement in pulmonary function. Also exercise can help to mobilize secretions because it increases minute ventilation. Secretion retention can predispose an older individual to disease, while exercise may further prevent decline of pulmonary function (6). Whereas, ventilatory muscle training in addition to lower extremity exercise training resulted in reduction in dyspnea, improved respiratory muscle strength and endurance,

Table 4. Spirometry, inspiratory muscle endurance and respiratory muscle strength in group (A) and group (B) after treatment.

	Group (A)	Group (B)	t value	p value
VC (L)	4.97 ± 0.75	3.58 ± 0.87	5.67	< 0.05
FEV1 (L)	3.88 ± 0.65	2.50 ± 0.72	4.13	< 0.05
MVV (L min ⁻¹)	96.42 ± 9.14	81.64 ± 10.21	7.52	< 0.05
PImax (cmH ₂ O)	90.12 ± 9.52	78.75 ± 10.35	6.85	< 0.05
PEmax (cmH ₂ O)	116.27 ± 12.33	106.82 ± 15.93	10.21	< 0.05
PEND (cmH ₂ O)	70.54 ± 8.26	62.15 ± 10.14	6.94	< 0.05

C, vital capacity, FEV1, forced expiratory volume in 1 s, MVV, maximum voluntary ventilation, PImax, maximum inspiratory pressure, PEmax, maximum expiratory pressure, PEND, pressure for greatest completed 2 min stage of incremental inspiratory muscle endurance test

increased exercise ability and improved health related quality of life (18).

In conclusion, application of breathing exercise with an incentive spirometer in addition to walking exercise can control age related respiratory muscles function changes in elderly.

REFERENCES

1. Janssens J. Aging of the Respiratory System: Impact on Pulmonary Function Tests and Adaptation to Exertion. *Clin Chest Med* 2005;26:469-84.
2. Maguire S, Slater B. Physiology of ageing. *Anaesth Intensive Care* 2010;11:290-2.
3. Betglumd D, Abbey D, Lebowitz M. Respiratory symptoms and pulmonary function in an elderly non smoking population. *Chest* 1999;115:49-59.
4. Delk K, Gevirtz R, tticks D. The effects of biofeedback assisted breathing retraining on lung function in patients with cystic fibrosis. *Chest* 1993;105:23-8.
5. Weindler J, Kiefer R. The efficacy of postoperative incentive spirometry is influenced by the device -specific imposed work of breathing. *Chest* 2001;119:1858-264.
6. Normandin E, Mccusker C, Connors M. An evaluation of two approaches to exercise conditioning in pulmonary rehabilitation. *Chest* 2002;121:1085-91.
7. Clanton T, Diaz P. Clinical assessment of the respiratory muscles. *Phys Ther* 1995;75:983-95.
8. Larson J, Kim M. Reliability of maximal inspiratory pressure. *Nurs Res* 1987;36:317-9.
9. Fiz J, Romero P, Gomez R. Indices of respiratory muscle endurance in healthy subjects. *Respiration* 1998; 65: 21-7.
10. Larson J, Covey M, Berry J. Discontinuous incremental threshold loading test: measure of respiratory muscle endurance in patients with COPD. *Chest* 1999; 115: 60-7.
11. Harik-Khan R, Wise R, Fozard J. Determinants of maximal inspiratory pressure. The Baltimore longitudinal study of aging. *Am J Respir Crit Care Med* 1998; 158:1459-64.
12. Bom A, Pinto A. Allergic respiratory diseases in the elderly. *Respiratory Medicine* 1999;103:1614-22.
13. Davies G, Bolton C. Brocklehurst's Textbook of Geriatric Medicine and Gerontology (Seventh Edition). Age-Related Changes in the Respiratory System 2010:97-100.
14. Watsford M, Murphy A, Pine M. The effects of ageing on respiratory muscle function and performance in older adults. *J Sci Med Sport* 2007;10: 36-44.
15. Igarashi I, Konishi A, Suwa K. The effects of incentive spirometry on pulmonary functions. *Masui* 1994;43:770-3.
16. Overend T, Anderson C, Luay D. The effect of incentive spirometry on postoperative pulmonary complications. *Chest* 2001;120:971-8.
17. Weiner P, Man A, Weiner M. The effect of incentive spirometer and inspiratory muscle training on pulmonary function after lung resection. *J Thoracic Cardiothoracic Surg* 1997;113:552-7.
18. Weiner P, Magadle R, Yauay N. The cumulative effect of long acting bronchodilators, exercise and inspiratory muscle training on the perception of dyspnea in patients with advanced chronic obstructive pulmonary disease. *Chest* 2000;118:672-8.
19. Donald M. Pulmonary rehabilitation. *Chest* 1998;113: 263S-8S.