ORIGINAL ARTICLE

The Effect of Additional Air Stacking Exercise on VO2 Max A Study on Elderly with Restrictive Pulmonary Disorder Who Had Deep Breathing Exercise

Lisa Nurhasanah[1], Sri Wahyudati[1]

[1] Physical Medicine and Rehabilitation Department, Medical Faculty of Diponegoro University, 50275 Semarang, Indonesia.

ABSTRACT

Introduction: Elderly people experience physiological changes that can cause or aggravate restrictive lung disorders. The prevalence of restrictive pulmonary disorders in the elderly increases to 175 per 100,000 cases. The increasing number of elderly people year by year in Indonesia is a special challenge in the world of health, particularly in terms of maintaining cardiovascular fitness that can be assessed via VO2 Max. This study aims to determine the effect of the addition of air stacking exercises to VO2 max of elderly with restrictive lung disorders who have performed deep breathing training. **Methods:** This study was a true experimental randomized pre- and post-test group design on the elderly with a restrictive lung disorder. Thirty subjects of elderly with restrictive lung disorder who have performed deep breathing training and qualified the inclusion and exclusion criteria were randomly divided into the experimental group who received additional air stacking exercise and the control group. Each group performed training 5 times a week for 4 weeks. A 6-minutes walk test was carried out before and after treatment to obtain the VO2 max value. **Results:** The difference in VO2 max value between the experimental group and the control group, before and after the treatment, suggested a significant difference ($p<0.05$). **Conclusion:** Additional air stacking exercise on the elderly with restrictive lung disorders who also performed deep breathing training, improved physical fitness.

Keywords: Air stacking exercise, Restrictive lung disease, Physical fitness, VO2 max

Corresponding Author:
Lisa Nurhasanah, MD
Email: lisanurhasanah.dr@gmail.com
Tel: +6282114618086

INTRODUCTION

The increasing number of elderly people each year in Indonesia poses a special challenge in the world of health (1). Physiological changes in the elderly can affect the respiratory system, such as kyphosis, stiffness in the chest wall, weakness of the respiratory muscles, etc. These changes can cause or deteriorate restrictive pulmonary disorder (2,3).

Restrictive pulmonary disorder results in a decrease in the amount of oxygen intake which affects the value of maximal oxygen uptake (VO2 max) (4,5). VO2 max is recognized as an international standard of reference to indicate one's physical fitness. VO2 max is affected by the ability of the body to uptake, to deliver, and to use the oxygen (5,6). One study conducted by Fatemi et al, in which 51 subjects divided into three groups of VO2 max level, i.e high, medium, and, low suggested a significant difference ($p<0.001$) in pulmonary function assessed by measuring the values of FEV1, FVC and FEV1/FVC where the lower the pulmonary function, the lower the level of VO2 max. Factors that affect VO2 max are genetic, age, sex, BMI level, physical activity, cardiovascular function, respiratory function, and musculoskeletal function (7).

One of the treatments for restrictive pulmonary disorder is to provide pulmonary rehabilitation. The frequent pulmonary rehabilitation has given as a home exercise program is deep breathing and air stacking exercises (8).

Air stacking exercise is a training that helps inhalation or a maximum blowing of air into the lungs. A study by Hyun Gyu Cha et al (2016) on the elderly suggested that there was a significant difference before and after 4-weeks of treatment of air stacking exercise to the respiratory function and the distance in a 6-minute walk test (9). Marques et al (2014), in a longitudinal study without control towards 18 patients with neuromuscular disorders such as spinal muscular atrophy (SMA) and congenital muscular dystrophy (CMD) who had a restrictive respiratory disorder, suggested that prescribing air stacking manually as a home program for 4-6 weeks can significantly improve the respiratory function including the value of FVC (10). Several studies that provide air stacking exercises in neuromuscular disease patients with restrictive pulmonary disorders have improved (11,12).

Currently, no one has examined the effect of adding air stacking exercise to the elderly with restrictive pulmonary disorders who had deep breathing exercises, to VO2 Max. The objective of this study was to analyze the changes in the difference in mean VO2 max values in the group that received the addition of water stacking exercise compared to the control group who got deep breathing only. The objective of this study was to analyze the difference of the VO2 max mean in the group receiving additional air stacking exercise compared to the control group who merely had deep breathing exercises.

MATERIALS AND METHODS

Participants

This study was a true experimental randomized pre- and post-test group design on the elderly with a restrictive pulmonary disorder. This study was approved by the Ethical commission Faculty of Medicine Diponegoro University No. 162/EC/FK-RSDK/IV/2018. Subjects were individuals age > 60 years old with a restrictive respiratory disorder who have performed deep breathing exercises twice a day, 5 times a week for 4 weeks. The sample amount was 15 people for each group.

Inclusion criteria were elderly people age > 60 years old, able to understand instructions, able to walk without assistance, having mild to moderate restrictive pulmonary disorders assessed from spirometry results, having no neuromuscular disorders and severe balance disorders that may interfere with the examination, not smoking, sedentary and willing to be included in the study by filling the informed consent. Exclusion criteria were the presence of visual impairment and hearing loss, having severe cardiovascular disorders assessed by the result of physical examination (e.g., unstable angina, blood pressure level > 160/100 mmHg, arrhythmia, heart failure [NYHA Class II, III and IV]), suffering from a severe illness that makes the patient impossible to take part in the study such as severe renal failure, severe liver disease (hepatic cirrhosis), uncontrolled diabetes mellitus, etc. And the dropout criteria: participants refuse to continue the training session until completion, attendance is less than 80% or attendance less than 32 times, and/or skipping practice 3 times in a row.

Procedures

The procedure of Deep Breathing exercise consists of several stages. First, the patient is requested to sit in a chair and put one hand over the abdomen (just below the ribs) and the other hand in the middle of the chest to feel the movements of the chest and stomach while breathing. The two patients are asked to take a deep breath through the nose for 4 seconds until the chest and abdomen felt maximally uplifted, keeping the mouth closed during inspiration, holding the breath for 2 seconds then exhaling through lips that are pressed together and slightly open while tightening (contracting) the abdominal muscles in 4 seconds. Repeated for 1 minute with a 2-second rest in each repetition, following with a two minutes rest period. These stages are called 1 cycle. The exercise is carried out in 3 cycles twice a day (15,16).

The procedure for the implementation of Air Stacking exercises are as follows: first, the patient is asked to sit upright. Second, after covering the mouth and nose tightly with the face mask, the patient is asked to take deep breaths, and then the assistant pumps the air to enter using an Ambu bag slowly, 2-3 times adjusting to the patient's tolerance. The patient is asked to give a signal when the patient feels that the air is inserted enough or if the assistant has felt there is resistance to the pump. These steps are called 1 cycle. Third, remove the mask, and then the patient is asked to do an effective cough. This exercise is done in 10 cycles, followed by a short break of about half to one minute between exercises, to allow recovery. Exercise must be repeated 2 times per day, before lunch and evening on an empty stomach. Exercise can be given by family members or caregivers, who have attended the training. Exercise must be carried out on conscious condition, on an empty stomach, and before bedtime (9,17).

Statistical analysis

The dependent variable in this study is VO2 Max. The free variable is the addition of air stacking exercises. Other risk factors studied were gender, nutritional status, pulmonary functional capacity, heart and lung structure and, heart rhythm. The study protocol was as follows: the selection of subjects who met criteria based on history taking, physical examination and, Spirometry examination; subjects were given an explanation of breathing exercises to be given, goals and benefits as well as research protocols, and not taking any therapy other than those given during the study; selected subjects who were willing to take part in the study were asked to sign the informed consent to take part in the study; after signing the informed consent, the subjects were randomized and divided into 2 groups; each group conducted a 6-minute walk test and deep breathing exercises were added in the experimental group. Each exercise was given twice a day, 5 days a week, for 4 weeks. The control group was given only deep breathing exercises 5 days a week for 4 weeks. The evaluation of VO2 max using a 6-minute walk test was done at the beginning before treatment and at the end of the 4th week of treatments. For each independent variable, univariate tests were carried out, namely gender, nutritional status, pulmonary functional capacity, heart and lung structure, and heart rhythm.

Data analysis included descriptive analysis, randomization, and hypothesis testing. Descriptive analysis was performed to see the frequency distribution of all observed variables, including gender, nutritional status, height, cardiovascular function, musculoskeletal function, pulmonary functional capacity, and VO2 max. Randomization was conducted to control confounding factors statistically. Distribution normality was performed using the Shapiro Wilk test for numerical data. If the data is normally distributed, then the test is performed using an unpaired t-test (independent t-test). If the data is not normally distributed, then the Mann Whitney test is carried out. (13,14).

For categorical data using a Chi-Square test, randomization is said to be successful if the value of p> 0.05. The hypothesis testing for numerical data performed with an independent t-test if the data was normally distributed and with Mann Whitney test if the data was abnormally distributed. The differences before and after treatment calculated with a paired t-test if the data distribution was normal or with a Wilcoxon test if the data distribution was not normal. Significance in this study was obtained if the value of p <0.05 with a 95% confidence interval (13).

The normality test was performed to the obtained data of VO2 max using the Shapiro-Wilk test. Following the normality test, a bivariate test was conducted toward the results of VO2 max between the experimental group and the control group, before and after the treatment (14).

RESULTS

This study was carried out at the Social Rehabilitation Center of Pucang Gading, Semarang, for 16 weeks, from Sunday, May 2, 2018, to the second week of August 2018. The study started by collecting primary data obtained from the history taking, physical examination, spirometry examination, and a 6-minute walk test which results converted into the value of VO2 max. Of 110 elderly people, only 30 of them met the criteria of inclusion and exclusion, consisted of 15 elderly people in the experimental group and 15 elderly people in the control group.

The experimental group received deep breathing exercises and addition of air stacking exercises while the control group only receives deep breathing exercises every day from Monday to Friday, twice a day for 4 weeks. A preliminary exercise to introduce motions was carried out once in both groups. The characteristics of the subjects of this study are illustrated in Table I.

There was no significant difference (p = 0.659) between the male and the female gender in the experimental group and the control group. The result of an independent t-test for the variables of age and IMT suggested that there was no significant difference as well in the experimental group and the control group, with the p-value are 0.297 and 0.953, respectively.

The result of the chest x-ray providing the images of lung and heart showed that there were no significant differences in the experimental group and the control group (p = 0.225). Heart rhythm obtained from ECG in the experimental group and the control group did not show a significant difference (p = 0.136). There was no difference in FVC value obtained from spirometry examination between both groups with a p-value are 0.950 and 1.000.

Table I : Characteristic of subjects

Variables	Groups		*p*
	Experimental (n=15)	Control (n=15)	
Gender			0,659¥
Male	4 (26,7%)	4(26,7%)	
Female	11 (73,3%)	11 (73,3%)	
Age (yo)	70,67±5,33	70,53±5,33	0,946§
IMT (kg/m²)	22,19±2,23	22,24±2,34	0,953§
Lung and heart structure			0,225¥
- Normal	7 (46,7%)	4 (26,7%)	
- Abnormal	8 (53,3%)	11(73,3%)	
Heart rhythm			0,136¥
- Normal	10 (66,7 %)	6 (40%)	
- Abnormal	5 (33,3%)	9 (60%)	
FVC(%)	62,06± 4,90	62,2±6,573)	0,950§

¥ Chi Square; §Independent t-test

The 6-minute walking test results in two groups

The Mann-Whitney test showed no significant difference for distance in a 6-minute walk test between both groups, p = 0.567.

Following the treatments, there were significant differences for the distance in a 6-minute walk test between the two groups with a p-value is 0.013. The difference in distance of a 6-minutes walk test, before and after the treatments, in the experimental group showed a significant difference (p = 0.000), whereas, in the control group, it was not significant (p = 0.504). The difference in distance in a 6-minute walk test between the experimental group and the control group showed a significant difference (p <0.05).

Table II : Changes in the results of 6 MWD test

Distance 6MWD (meter)	Mean±SD / Median (Min –Max)		p)
	Experimental (n=15)	Control (n=15)	
Pre	364 (322-456)	352 (324-474)	0,567*
Post	386 (332-478)	375 (326-480)	0,013*
p b)	0,000§	0,504#	
Delta (post-pre)	20 (6-79)	2 (0 - 5)	0,000*

*Mann-Whitney test; # wilcoxon test §Dependent t-test

Table III : Changes in the results of VO2 max

VO2 max value (ml/kg/min)	Mean±SD / Median (Min –Max)		p)
	Experimental (n=15)	Control (n=15)	
• Pre	31,4 (30,.6-33,2)	31,1 (30,6-33,5)	0,539*
• Post	31,8 (30,7-33,6)	31,3 (30,6-33,7)	0,018*
p b)	0,000§	0,858#	
• Delta (post-pre)	0,4 (0,1-1,6)	0,0 (0,0 - 0,1)	0,000*

*uji Mann-Whitney ; # uji Wilcoxon; §Dependent t-test

The value of VO2 max in two groups

From the results of the Mann-Whitney test, the value of VO2 max before the treatment between the experimental and control groups showed no significant difference with the value of p = 0.519, while the VO2 max value after treatment showed a significant difference with the p-value = 0.018. The value of VO2 max before and after breathing exercises showed a significant difference with the value of p <0.05 in the experimental group. However, there was no significant difference (p> 0.05) in the control group. The difference in the value of VO2 max between the experimental group and the control group showed a significant difference (p <0.05).

DISCUSSION

VO2 max is an international standard of reference to show one's physical fitness. VO2 max is determined by oxygen delivery capacity and oxygen usage. One of the oxygen delivery capacities is determined by oxygen intake which is determined by lung functional ability. This, as revealed by Fatemi et al. in his study, also concludes that the lower the value of lung function, the lower the VO2 max value of a person. The majority of oxygen consumed in VO2 max is used for the contraction of the muscles to move. Hence, one way to calculate VO2 max is by calculating the distance of the walk test for 6 minutes. When pulmonary function decreases, the body's ability to uptake oxygen in the air during inspiration reduces, so the oxygen delivered to the heart which then distributed to the muscle used for walking will also decrease, and the body will become tired quickly as well as the distance one can travel will reduce (10,18).

Deep breathing exercises can effectively increase the movement of the ribs, allowing better airflow into and out of the lungs. During deep breathing exercises, the diaphragm contracts, along with the intercostal muscles reducing the pressure in the chest cavity. This allows air to enter the lungs and fill the lung capacity more optimally. With deep breathing exercises, there is an increased need for oxygen in the respiratory muscles that work. This is the mechanism that causes an increase in VO2 max (15,19).

The addition of air stacking exercise is an exercise that helps inhalation, which is carried out by filling a person's lungs with an air volume that exceeds the volume a person can take by breathing naturally. The tool used to put more air into the lungs is an Ambu bag (bag valve mask). During air stacking exercises, the lungs are expanding as much as possible by breathing consecutively without exhalation. After the lungs expand maximally, the volume of compressed air is released by the force of the expiratory muscles, giving rise to coughing with the recoil of the lungs and chest wall. Periodic expansion of the lung with air stacking exercise decreases basal atelectasis and maintains compliance with pulmonary and chest wall. With this exercise, oxygen intake will increase which will increase VO2 max (11,13).

CONCLUSION

In group who had an additional air stacking exercise on the elderly with restrictive lung disorders who also performed deep breathing training, there was an increase in VO2 max value of 0.52 ± 0.38 ml/kg/minute or in other words, able to make a person travel a distance of 26.33 ± 18.71 meters further in a 6-minute walk test compared to before exercise performed.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to the Faculty of Medicine, Diponegoro University Indonesia dan Social Rehabilitation Centre Pucang Gading Semarang Indonesia for their cooperation and valuable assistance in completing this research.

REFERENCES

1. Research and Development Department Indonesia's Minister of Health. Hasil Utama Riset Kesehatan Dasar. Minister of Health RI [Internet]. 2018;1–100. Available from:http://www.depkes.

go.id/resources/download/info-terkini/hasil-riskesdas-2018.pdf
2. Sharma G, Goodwin J. Effect of aging on respiratory system physiology and immunology. Clin Interv Aging. 2006;1(3):253–60.
3. Gonzales P. Physical Medicine and Rehabilitation Board Review. 3rd ed. Cuccurullo SJ, editor. New York: Demosmedical; 2015.
4. Freitas FS, Ibiapina CC, Alvim CG, Britto RR, Parreira VF. Relationship between cough strength and functional level in elderly. Rev Bras Fisioter 2010;14(6):470-476.
5. Ishikawa Y, Bach JR, Komaroff E, Miura T, Jackson-Parekh R. Cough augmentation in Duchenne muscular dystrophy. Am J Phys Med Rehabil 2008;87(9):726-730.
6. Bach JR, Mahajan K, Lipa B, Saporito L, Goncalves M, Komaroff E. Lung insufflation capacity in neuromuscular disease. Am J Phys Med Rehabil 2008;87(9):720-725.
7. Fatemi R, Shakerian S, Ghanbarzade M, Habibi A. The comparison of dynamic volumes of pulmonary function between different levels of maximal oxygen uptake. Int Res J Appl Basic Sci. 2012;3(3):667–74.
8. AACPR. Guidelines For Pulmonary Rehabilitation Programs. 4 ed. Robertson LD, editor. United States: Human Kinetics; 2011.
9. Kim H. The Effects of Air Stacking Exercise on Pulmonary Function in Elderly Adults. Journal of the Korean Society of Physical Medicine. 2016;11(4):55–64
10. Marques TBC, Neves J de C, Portes LA. Air stacking: effects on pulmonary function in patients with spinal muscular atrophy in patients with congenital muscular dystrophy. J Bras Pneumol. 2014;40(5):528–34.
11. Sang-Kyun An, Won-Seob Shin. Effect of air stacking training on pulmonary function, respiratory strength and peak cough flow in persons with cervical spinal cord injury. Phys Ther Rehabil Sci. 2018, 7 (4), 147-153
12. Sarmento A, Resqueti V, Duorado M, Aliverti A. Effects of Air Stacking Maneuver on Cough Peak Flow and Chest Wall Compartmental Volumes of Subjects With Amyotrophic Lateral Sclerosis. Archives of Physical Medicine and Rehabilitation. 2017: 98(11):2237-46.
13. Sarmento A, Andrade A, Lima N, Aliverti A, Freitas G. Air Stacking: A Detailed Look Into Physiological Acute Effects on Cough Peak Flow and Chest Wall Volumes of Healthy Subjects. Respiratory Care Journal. 2017;62(4).434-42.
14. Sopiyudin. Statistik untuk kedokteran dan kesehatan. 5 ed. Jakarta: Salemba Medika; 2011.
15. Sastroasmoro Sudigdo IS. Dasar-dasar Metodologi Penelitian Klinis. 4 ed. Jakarta: Sagung Seto; 2011.
16. Kang SW, Bach JR. Maximum insufflation capacity: vital capacity and cough flows in neuromuscular disease. Am J Phys Med Rehabil 2000;79(3):222-227.
17. Fauroux B, Guillemot N, Aubertin G, Nathan N, Labit A, Cle´ment A, Lofaso F. Physiologic benefits of mechanical insufflation-exsufflation in children with neuromuscular diseases. Chest 2008;133(1):161-168.
18. Jeong J, Yoo W. Effects of air stacking on pulmonary function and peak cough flow in patients with cervical spinal cord injury. J Phys Ther Sci. 2015;17(6):1951–52.
19. Armstrong A. Developing a breath-stacking system to achieve lung volume recruitment. Br J Nurs. 2009;18(19):1166–9.