

Effects of air stacking on pulmonary function and peak cough flow in patients with cervical spinal cord injury

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Abstract. [Purpose] This study evaluated the effects of air stacking on pulmonary function and peak cough flow in patients with cervical spinal cord injury. [Subjects] Twenty-six patients were included in the study and were randomized into experimental (n = 14) and control (n = 12) groups. [Methods] Both groups performed therapeutic exercises: the control group performed incentive spirometry, while the experimental group performed 20 repetitions of air stacking exercise twice a day. The training for both groups continued for 5 days a week for 6 weeks. [Results] Forced vital capacity and peak cough flow increased significantly in the experimental group compared to the controls. All within-group variables in the experimental group differed significantly at 6 weeks compared to baseline, while in the control group only Forced vital capacity differed significantly at 6 weeks compared to baseline. [Conclusion] Air stacking exercise significantly improved pulmonary function and peak cough flow in patients with a cervical spinal cord injury.

Key words: Air stacking exercise, Cervical spinal cord injury, Respiratory rehabilitation

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INTRODUCTION

The number of respiratory complications experienced during initial acute-care hospitalization for cervical spinal cord injury (CSI) is a more important determinant of the length of stay and hospital costs than degree of the injury¹⁾. In patients with CSI, the inability to cough out airway secretions effectively is the main cause of respiratory complications, such as respiratory failure leading to death, because effective coughing is an important host defense mechanism for clearing the airway²⁾. The phases of coughing can be classified as inspiration, compression, and expiration. During the inspiration phase, normal subjects have pre-cough volumes that are 85–90% of their inspiratory capacity³⁾. Air stacking (AS) exercise increases the capacity to stack air with deep insufflations and can improve cough effectiveness⁴⁾. Previous studies have focused on patients with congenital or progressive diseases, such as amyotrophic lateral sclerosis (ALS) and Duchene muscular dystrophy. Therefore, this study evaluated how AS affects pulmonary function and peak cough flow (PCF) in patients with CSI.

SUBJECTS AND METHODS

The recruitment period for this study was from August to October 2014. This study was approved by the Inje University Faculty of Health Science Human Ethics Committee and all subjects provided written informed consent before participating. Thirty CSI patients who understood the details of the study consented to participate. Subjects averaged 47.58 ± 11.74 years of age, 164.73 ± 17.19 cm in height, and 56.69 ± 14.12 kg in weight, and had an average body mass index (BMI) of 54.00 ± 13.74 . Patients were excluded if they had concomitant intrinsic lung diseases, could not hold their breath due to vocal cord paralysis, were intubated or had a tracheostomy, or took medications that affected pulmonary function. The 30 patients who consented to participate were randomized into two groups using computer-generated tables. The randomization codes were kept by an independent member of the study team and released after consent was obtained. The subjects were assessed by a physical therapist who was blinded to all group information. The control group performed 20 repetitions of incentive spirometry (IS) twice a day, while the experimental group performed 20 repetitions of AS twice a day. Both groups trained for 5 days a week, for 6 weeks. During the 6-week study, one subject from the experimental group and three subjects from the control group were excluded based on the exclusion criteria, therefore, a total of 14 subjects in the experimental group and 12 subjects in the control group completed the study.

Pulmonary function was assessed using MicroLab (Micro Medical, Cambridge, UK). Forced vital capacity

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(FVC) and forced expiratory volume in 1 second (FEV1) were measured in accordance with the American Thoracic Society guidelines⁵). PCF was assessed using a peak flow meter (Micro Medical, Cambridge, UK). PCF has been used as a measure of huff strength, and the effectiveness of airway clearance depends largely on PCF⁶).

All data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 12.0 (SPSS; Chicago, IL, USA). The statistical significance level was set at $\alpha = 0.05$. The homogeneity of the general characteristics between the two groups was analyzed using the χ^2 test and independent t-test. The Mann-Whitney U-test was used to confirm the homogeneity of the variables between the two groups before the experiment. Differences in the changes within each group from baseline to 6 weeks were assessed using two-way repeated measures analysis of variance (ANOVA).

RESULTS

Table 1 compares the variables for the two groups before and after the experiment. FVC and PCF increased significantly ($p < 0.05$) in the experimental group compared to the control group. In the within-group comparisons, all of the variables in the experimental group differed significantly at 6 weeks compared to baseline, while in the control group only FVC differed significantly at 6 weeks compared to baseline ($p < 0.05$).

DISCUSSION

Kang et al.⁴) reported that a daily program of AS in patients with neuromuscular disease increased maximum insufflation capacity and assisted PCF. Additionally, the extent of the increase in maximum insufflation capacity correlated with an increased assisted cough flow. It is likely that both of our groups showed significant increases in FVC because both exercises increased lung capacity. Additionally, AS maintained pulmonary compliance by inflating the lungs maximally in the experimental group. Consequently, the increase in FVC in the experimental group was significantly more than that in the control group. Marques et al.⁷) instructed 18 patients with neuromuscular disease to perform routine AS at home for 4–6 months and found that PCF increased significantly by 9.9%. In our study, the increase in PCF was 27.3% in the experimental group versus 4.2% in the control group. The difference in the results of these two studies can likely be attributed to the different types of patients included as well as differences between the locations of patient management. Neuromuscular disease is a progressive congenital disease, while CSI is caused accidentally. Additionally, Marques et

Table 1. Comparison of the variables between the two groups

	Group	Baseline	After 6 weeks	Source
		Mean (SD)	Mean (SD)	
FVC	Exp	1.49 (0.81)	1.85 (0.91)	time*
(L)	Cont	1.67 (0.77)	1.83 (0.76)	group, time*
FEV1	Exp	1.41 (0.84)	1.69 (0.87)	time*
(L)	Cont	1.41 (0.84)	1.62 (0.82)	group*, time
PCF	Exp	204.2 (128.7)	260.7 (126.0)	time*
(L/min)	Cont	239.5 (142.4)	249.1 (109.7)	group*, time*

* $p < 0.05$

al.⁷) managed their subjects at home, so the effects of intervention might have been less than in subjects managed in hospital. Park et al.⁸) reported that among patients with CSI, PCF was correlated with inspiratory muscular function. It is likely that our experimental group obtained higher PCF values because AS training for 6 weeks improved inspiratory capacity more effectively than IS.

Our study has several limitations. First, the number of subjects was small, and it is difficult to generalize the results because the study was performed in a single center. Second, all the subjects had cervical cord injuries only, so we cannot apply our results to other pathological conditions. In conclusion, in patients with CSI, AS exercise led to significantly improved pulmonary function in terms of PCF.

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