



Original Article

The effect of lumbar stabilization exercise on the pulmonary function of stroke patients

DAE-SIK OH, PT, MD¹⁾, SI-EUN PARK, PT, PhD^{2)*}

¹⁾ Department of Physical Therapy, Sugi Woori Hospital, Republic of Korea

²⁾ Department of Physical Therapy, Pohang College: 60 Sindeok-ro, Heunghae-eup, Buk-gu, Pohang-si 791-711, Republic of Korea

Abstract. [Purpose] This study was aimed at assessing the effect of lumbar stabilization exercise on the pulmonary function of stroke patients. [Subjects and Methods] The subjects were randomly allocated into lumbar stabilization exercise group and a general physical therapy group. The program consisted of 30-min sessions conducted 3 days a week for 8 weeks. Pulmonary function was assessed based on lung performance parameters, including forced vital capacity, forced expiratory volume at 1 second, ratio of forced expiratory volume at 1 second to forced vital capacity, and peak expiratory flow. [Results] In the assessment of pulmonary function, the values of all the lung performance parameters were significantly increased in the lumbar stabilization exercise group but were significantly decreased in the general physical therapy group. [Conclusion] These results indicate that lumbar stabilization exercise had a more positive effect on pulmonary function than general physical therapy.

Key words: Stroke, Lumbar stabilization exercise, Pulmonary function

(This article was submitted Feb. 4, 2016, and was accepted Mar. 12, 2016)

INTRODUCTION

Stroke is a leading cause of major disabilities in social, psychological, and physical functions¹⁾. The decline in the pulmonary function of stroke patients is caused by reduced physical activity²⁾. Meanwhile, the decline in the cardiopulmonary function of these patients is related to decreased oxygen transport ability caused by prolonged bed rest³⁾. Respiration provides oxygen for activities of daily living (ADL); as a result, respiratory disturbances influence patients' ADL. Therefore, respiratory problems are crucial factors in the rehabilitation and survival of stroke patients⁴⁾. Kim et al. reported that stroke patients exhibited a respiratory pattern of restrictive lung disease. The characteristics of restrictive lung disease include decreased forced vital capacity (FVC)⁵⁾. In addition, the stroke patients in their study showed reduced FVC and peak expiratory flow (PEF)⁴⁾.

Various physical therapies to improve the pulmonary function have been applied, such as thoracic spine mobility exercises and respiratory exercises including diaphragm breathing, ventilator muscle training, glossopharyngeal breathing and pursed-lip breathing⁶⁾. In addition, machines such as resistance breathing equipment, reverse testing equipment, and incentive spirometer are used in breathing therapies⁷⁾.

Respiratory impairment causes weakening of trunk muscles⁸⁾. Deep abdominal muscle strengthening exercise was effective at increasing vital capacity. Especially the transverse abdominis muscle influences the partial stabilization of the lumbar spine⁹⁾. The transverse abdominis, internal oblique, and external oblique muscles stabilize the trunk. In particular, the transverse abdominis muscle, together with the multifidus muscle, plays a major role in stabilizing the lumbar region¹⁰⁾. Among other expiratory muscles (rectus abdominis, internal oblique, and external oblique), the transverse abdominis muscle is the most active during easy breathing¹¹⁾. It has the largest activity change relative to other abdominal muscles, even during maximal inspiratory breathing¹²⁾. Gollee et al. reported that abdominal muscle stimulation also improved the lung function

*Corresponding author. Si-Eun Park (E-mail: si-yaa@hanmail.net)

©2016 The Society of Physical Therapy Science. Published by IPEC Inc.

This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License <<http://creativecommons.org/licenses/by-nc-nd/4.0/>>.

of paretic patients with decreased functional residual capacity¹³).

In previous studies on stroke patients, respiratory therapies that used various breathing exercises were reported. However, research on the clinical applications of general exercise therapy is lacking. The present study aimed to verify the efficacy of lumbar stabilization exercise (LSE) and LSE with abdominal stimulation used in clinical practice, and to identify the effects of the LSE method on the pulmonary function of stroke patients.

SUBJECTS AND METHODS

This study was conducted with patients from B Hospital (Suwon, Gyeonggi-do) who had had a stroke >6 months previously. The subjects selected were those without orthopedic diseases such as congenital defects involving the thoracic cage or fractured ribs, and those who scored >24 points in the Korean version of the Mini-Mental State Examination. The study purpose and methods were explained to the subjects, and only those who consented to participate were included in the study. The study protocol was approved by the local ethics committee of the Yongin University (2-1040966-AB-N-01-201503-HSR-026-1).

The subjects were 40 stroke patients. They were randomly and equally divided into two groups, namely a LSE group and a general physical therapy (GPT) group. However, during the study, two subjects were discharged from the hospital before the study completion and one subject dropped out of the study. As a result, 18 subjects in the LSE group and 19 subjects in the GPT group underwent the trial. The intervention was conducted three times per week, for a total of 8 weeks. The general characteristics of the subjects are shown in Table 1.

The LSE was designed according to the method of McGill and Karpowicz¹⁴. Eight step exercises were performed (Table 2; Fig. 1). The LSE was performed after a 30-min physical therapy. Each step was repeated three times. The subjects performed a 5-min stretching before and after the exercise. Six physical therapists with more than 1 year of experience in clinical trials were selected for this study. The subjects in the GPT group performed general physical therapies that are normally performed at rehabilitation centers, such as neurodevelopment treatment, mat, and gait training, for 30 min after physical therapy.

In order to assess pulmonary function, Fitmate MED (COSMED, Italy) was used to measure FVC, forced expiratory volume at 1 second (FEV1), FEV1/FVC ratio, and PEF. All pulmonary function measurements were performed with the subjects in the sitting position.

The subject waited for the start signal while holding the mouthpiece as tightly as possible to prevent air from escaping through the mouth while staring straight ahead without breathing through the nose. While the subjects were waiting for the start signal, the research inspectors asked them to take normal breaths three times and to breathe in as much as they could and exhale for more than 6 seconds. When the start signal was given, the subjects took three normal breaths, inhaled as much as they could, and exhaled for more than 6 seconds. The inspectors made sure that the subjects exhaled for at least 6 seconds, and the average of three measurements was calculated for each round. Three measurements were performed, once before, during, and after the exercise.

Table 1. General characteristics of the subjects

	LSE group	GPT group
Gender (male/female)	10 / 8	12 / 7
Age (years)	53.7 ± 7.7	58.4 ± 6.3
Weight (kg)	67.0 ± 9.8	68.6 ± 8.8
Height (cm)	165.5 ± 10.7	164.4 ± 8.8
Time since stroke (months)	17.8 ± 6.7	15.0 ± 5.6
Affected side (left/right)	12 / 6	11 / 8
MMSE-K (score)	26.8 ± 1.6	27.2 ± 1.7
K-MBI (score)	77.5 ± 14.7	75.5 ± 13.8
GDS (score)	1.6 ± 0.8	1.8 ± 0.7

Data are presented as mean ± SD.

LSE: lumbar stabilization exercise, GPT: general physical therapy, MMSE-K: Mini-Mental State Examination–Korean version, K-MBI: Korean version of the Modified Barthel Index, GDS: global deterioration scale



Fig. 1. Lumbar stabilization exercise program

For data processing, the SPSS version 20.0 software for Windows was used. Descriptive statistics were processed by using the general characteristics of the subjects. The independent t-test was used to compare the change in the values of the pulmonary function parameters between the groups. One-way repeated-measures analysis of variance was used to compare in-group data before, during (4 weeks), and after (8 weeks) the intervention. The significance level was set at $\alpha=0.05$.

RESULTS

In this study, the pulmonary functions of the stroke patients in the LSE or GPT groups were examined. The results of the study are shown in Table 3.

In the pulmonary function test, the LSE group showed significant differences in the FVC measurements between before, during (4 weeks), and after (8 weeks) exercise therapy ($p<0.05$). The GPT group did not show any significant differences ($p>0.05$). The differences in FVC between the two groups were significant during (4 weeks) and after (8 weeks) exercise therapy ($p<0.05$).

In the FEV1 measurements, the LSE group showed significant differences between before, during (4 weeks), and after (8 weeks) exercise therapy ($p<0.05$); and The GPT group, between before and during (4 weeks) exercise therapy ($p<0.05$), and between before and after (8 weeks) exercise therapy ($p<0.05$). However, in the GPT group, the FEV1 values were decreased. The differences between the two groups were significant during (4 weeks) and after (8 weeks) exercise therapy ($p<0.05$).

In the FEV1/FVC measurements, the LSE group showed significant differences between before and after (8 weeks) exercise therapy ($p<0.05$), and between during (4 weeks) and after (8 weeks) exercise therapy ($p<0.05$). The GPT group showed significant differences between before and during (4 weeks) exercise therapy ($p<0.05$), and between before and after (8 weeks) exercise therapy ($p<0.05$). However, in the GPT group, the FEV1/FVC values were decreased. The differences in FEV1/FVC ratio between the two groups were significant during (4 weeks) and after (8 weeks) exercise therapy ($p<0.05$).

In the PEF measurements, the LSE group showed significant differences between before and after (8 weeks) exercise therapy ($p<0.05$), and between during (4 weeks) and after (8 weeks) exercise therapy ($p<0.05$). The GPT group did not show any significant differences ($p>0.05$). The differences in PEF measurements between the two groups were significant after the exercise period (8 weeks; $p<0.05$).

Table 2. Lumbar stabilization exercise program

Warm-up (5 min)	Stretching
Main exercise (30 min)	1. Transverse abdominis contraction exercises
	2. Bridge exercise
	3. Bridge exercise with one leg up
	4. Exercise of consecutively lifting arms and legs in the supine position
	5. Exercise of pushing arms and legs in the supine position
	6. Exercise of lifting legs in the supine position
	7. Exercise of consecutively extending arms and legs in the prone position
	8. Exercise of lifting arms and legs on the same side while in the prone position
Cool- down (5 min)	Stretching

Table 3. Comparison of pulmonary function test results

		Pre-test	4 weeks	8 weeks	Contrast
FVC (L)	LSE group*	3.4 ± 1.1	3.6 ± 1.2*	4.0 ± 1.1*	1<2<3
	GPT group	3.1 ± 0.9	2.8 ± 0.6	2.8 ± 0.5	
FEV1 (L)	LSE group*	2.3 ± 0.9	2.5 ± 1.0*	2.9 ± 0.9*	1<2<3
	GPT group	1.9 ± 0.7	1.6 ± 0.5*	1.6 ± 0.4*	1>2, 1>3
FEV1/FVC (%)	LSE group*	67.2 ± 13.7	70.8 ± 8.7	74.3 ± 11.2*	1<3, 2<3
	GPT group	66.2 ± 15.3	57.6 ± 13.7*	60.0 ± 12.9*	1>2, 1>3
PEF (L/s)	LSE group*	3.3 ± 1.6	3.5 ± 1.4	4.2 ± 1.4*	1<3, 2<3
	GPT group	3.1 ± 1.5	2.7 ± 1.4	2.8 ± 1.1	

The numbers under the Contrast column indicates the following: 1: pretest, 2: 4 weeks, and 3: 8 weeks.

FVC: forced vital capacity, FEV1: forced expiratory volume at 1 second, PEF: peak expiratory flow

*Significant difference, $p<0.05$

DISCUSSION

For stroke patients, cardiopulmonary function is an important issue for preservation of life⁵). Lanini et al. observed significant decreases in maximal respiratory pressure in stroke patients as compared with healthy control subjects¹⁵).

Impaired pulmonary function may be a consequence of weakened respiratory muscles and postural trunk dysfunction¹⁶). Abdominal muscle strengthening exercises were shown to have positive effects such as improvement in pulmonary function¹⁷), and LSE has been used in clinical practice with abdominal muscle stimulation. Gollee et al. suggested the application of abdominal muscle stimulation to increase expiratory flow and tidal volume in order to improve respiratory function¹³). Accordingly, this study examined the effect of LSE on the pulmonary function of stroke patients. To assess pulmonary function, FVC, FEV1, FEV1/FVC, and PEF were measured.

In this study, the LSE group showed significant increases in FVC, FVC, FEV1/FVC, and PEF values after the exercise intervention, indicating that LSE had a positive effect on the pulmonary function of the stroke patients. By contrast, the GPT group showed a decline in the FVC, FVC, FEV1/FVC, and PEF values after the exercise intervention, indicating that GPT alone cannot improve the pulmonary function of stroke patients.

Kim and Lee reported that deep abdominal muscle training was effective at enhancing pulmonary function⁹). Jung et al. reported that inspiratory muscle training (IMT) with abdominal stimulation improved the pulmonary function of chronic stroke patients. In their study, the subjects who received IMT with abdominal stimulation showed significant increases in FEV1, PEF, and FEF¹⁸). These findings are consistent with those of this study. In addition, the co-contraction of the abdominal muscles fixes the trunk and reduces the stress on the spine¹⁹). On the other hand, Kulnik et al. reported that respiratory muscle training did not improve pulmonary function and cough function in patients with acute stroke²⁰). This means that LSE have a more positive effect on pulmonary function than respiratory muscle exercise.

Song and Park reported that chest resistance and expansion exercises were effective for improving pulmonary function and trunk control ability in stroke patients²¹). Seo et al. reported that a combination of inspiratory diaphragm exercise and expiratory pursed-lip breathing exercise was effective for strengthening weakened pulmonary functions in the rehabilitation of patients with neurological disease²²). With these findings, it is hoped that in future studies, the effect of combining respiratory muscle strengthening exercises and LSEs in stroke patients will be investigated.

The findings of this study indicate that LSE may be a more appropriate therapeutic method than GPT for improving pulmonary function in stroke patients. Owing to the limited sample size of this study, the study finding is difficult to generalize to all stroke patients. Therefore, studies with larger patient samples that investigate long-term therapies and their benefits to stroke patients are needed. In addition, further studies are needed to include additional exercise combinations for both lumbar stabilization and respiratory muscle strengthening.

REFERENCES

- 1) Duncan PW, Homer RD, Reker DM: Adherence to post acute rehabilitation guidelines is associated with functional recovery in stroke. *Stroke*, 2002, 33: 167–178. [[CrossRef](#)]
- 2) Kashiwara H, Haruna Y, Suzuki Y, et al.: Effects of mild supine exercise during 20 days bed rest on maximal oxygen uptake rate in young humans. *Acta Physiol Scand Suppl*, 1994, 616: 19–26. [[Medline](#)]
- 3) Ferretti G, Girardis M, Moia C, et al.: Effects of prolonged bed rest on cardiovascular oxygen transport during submaximal exercise in humans. *Eur J Appl Physiol Occup Physiol*, 1998, 78: 398–402. [[Medline](#)] [[CrossRef](#)]
- 4) Yoon JA, Park JS, Lee DH, et al.: Comparisons of respiratory function and activities of daily living between spinal cord injury and stroke patients and normal elderly people. *J Phys Ther Sci*, 2012, 24: 465–469. [[CrossRef](#)]
- 5) Kim K, Fell DW, Lee JH: Feedback respiratory training to enhance chest expansion and pulmonary function in chronic stroke: a double-blind, randomized controlled study. *J Phys Ther Sci*, 2011, 23: 75–79. [[CrossRef](#)]
- 6) Kisner C, Colby LA: *Therapeutic exercise: Foundations and techniques*, 3rd ed. Philadelphia. FA Davis Company, 1996.
- 7) Kohl J, Koller EA, Brandenberger M, et al.: Effect of exercise-induced hyperventilation on airway resistance and cycling endurance. *Eur J Appl Physiol Occup Physiol*, 1997, 75: 305–311. [[Medline](#)] [[CrossRef](#)]
- 8) Teixeira-Salmela LF, Parreira VF, Britto RR, et al.: Respiratory pressures and thoracoabdominal motion in community-dwelling chronic stroke survivors. *Arch Phys Med Rehabil*, 2005, 86: 1974–1978. [[Medline](#)] [[CrossRef](#)]
- 9) Kim E, Lee H: The effects of deep abdominal muscle strengthening exercises on respiratory function and lumbar stability. *J Phys Ther Sci*, 2013, 25: 663–665. [[Medline](#)] [[CrossRef](#)]
- 10) Hides JA, Richardson CA, Jull GA: Multifidus muscle recovery is not automatic after resolution of acute, first-episode low back pain. *Spine*, 1996, 21: 2763–2769. [[Medline](#)] [[CrossRef](#)]
- 11) Abe T, Kusuhara N, Yoshimura N, et al.: Differential respiratory activity of four abdominal muscles in humans. *J Appl Physiol* 1985, 1996, 80: 1379–1389. [[Medline](#)]
- 12) Kaneko H, Satou H, Maruyama H: Reliability of lateral abdominal muscles thickness measurement using ultrasonography. *Rigakuryoho Kagaku*, 2005, 20: 197–201. [[CrossRef](#)]
- 13) Gollee H, Hunt KJ, Fraser MH, et al.: Abdominal stimulation for respiratory support in tetraplegia: a tutorial review. *J Autom Contr*, 2008, 18: 85–92. [[Cross-](#)

[Ref\]](#)

- 14) McGill SM, Karpowicz A: Exercises for spine stabilization: motion/motor patterns, stability progressions, and clinical technique. *Arch Phys Med Rehabil*, 2009, 90: 118–126. [\[Medline\]](#) [\[CrossRef\]](#)
- 15) Lanini B, Bianchi R, Romagnoli I, et al.: Chest wall kinematics in patients with hemiplegia. *Am J Respir Crit Care Med*, 2003, 168: 109–113. [\[Medline\]](#) [\[Cross-Ref\]](#)
- 16) Britto RR, Rezende NR, Marinho KC, et al.: Inspiratory muscular training in chronic stroke survivors: a randomized controlled trial. *Arch Phys Med Rehabil*, 2011, 92: 184–190. [\[Medline\]](#) [\[CrossRef\]](#)
- 17) Kim KS, Kwon OY, Yi CH: Effect of abdominal drawing-in maneuver on peak expiratory flow, forced expiratory volume in 1 second and pain during forced expiratory pulmonary function test in patients with chronic low back pain. *Phys Ther Korea*, 2009, 16: 10–17.
- 18) Jung JH, Shim JM, Kwon HY, et al.: Effects of abdominal stimulation during inspiratory muscle training on respiratory function of chronic stroke patients. *J Phys Ther Sci*, 2014, 26: 73–76. [\[Medline\]](#) [\[CrossRef\]](#)
- 19) Hodges PW, Butler JE, McKenzie DK, et al.: Contraction of the human diaphragm during rapid postural adjustments. *J Physiol*, 1997, 505: 539–548. [\[Medline\]](#) [\[CrossRef\]](#)
- 20) Kulnik ST, Birring SS, Moxham J, et al.: Does respiratory muscle training improve cough flow in acute stroke? Pilot randomized controlled trial. *Stroke*, 2015, 46: 447–453. [\[Medline\]](#) [\[CrossRef\]](#)
- 21) Song GB, Park EC: Effects of chest resistance exercise and chest expansion exercise on stroke patients' respiratory function and trunk control ability. *J Phys Ther Sci*, 2015, 27: 1655–1658. [\[Medline\]](#) [\[CrossRef\]](#)
- 22) Seo KC: The effects of combination of inspiratory diaphragm exercise and expiratory pursed-lip breathing exercise on pulmonary functions of stroke patients. *J Phys Ther Sci*, 2013, 25: 241–244. [\[CrossRef\]](#)