



Original Article

# The effects of breathing with mainly inspiration or expiration on pulmonary function and chest expansion

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**Abstract.** [Purpose] This study aimed to determine the effects of inspiration- and expiration-oriented breathing on pulmonary function and chest expansion. [Subjects and Methods] Twenty healthy male university students were divided randomly into inspiration-oriented and expiration-oriented breathing groups. Their pulmonary function and chest size during inspiration or expiration were evaluated and then re-evaluated after 15 minutes of breathing exercise five times a week for four weeks. [Results] The breathing with mainly inspiration group (BMIG) showed significant differences in chest size during inspiration (CSI), chest expansion values (CEVs), forced vital capacity (FVC), forced expiratory volume in one second (FEV<sub>1</sub>), and peak expiratory flow (PEF) after four weeks. The breathing with mainly expiration group (BMEG) showed significant differences in all measured variables except CSI. Comparison of the groups after exercise showed that the BMEG demonstrated differences from the BMIG in chest size during expiration (CSE), CEV, and PEF. Comparison of the changes in variables after exercise showed that the BMEG demonstrated significantly different changes in CSE, CEV, FEV<sub>1</sub>/FVC, and PEF. The BMIG showed a significantly different change in FVC. [Conclusion] Although both groups demonstrated improvements in pulmonary function and chest expansion, inter-group differences were observed. Therefore, inspiration- or expiration-oriented breathing may be recommended differently according to the desired outcome.

**Key words:** Expiration, Inspiration, Pulmonary function

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## INTRODUCTION

Breathing is a physiological function that plays the important role of removing carbon dioxide and supplying oxygen via the circulation<sup>1)</sup>. A number of studies on negative changes in the respiratory system with advancing age have been published<sup>2-5)</sup>. To slow down these changes, deep and slow breathing via yoga can be helpful; it can also reduce stress, anxiety, post-traumatic stress, chronic pain, and depression<sup>6)</sup>. This indicates that deep and slow breathing affects the autonomic nervous system differently from habitual fast and shallow thoracic respiration<sup>7)</sup>. A previous study has also suggested that slow breathing can activate parasympathetic functions and inhibit sympathetic functions to a greater extent than fast breathing, which has no functional gain<sup>8)</sup>. There are many exercise methods for the improvement of respiratory function, and applying heavier loads to the diaphragm and inspiration synergist muscles can improve muscle strength and endurance<sup>9)</sup>. Exhalation and inhalation exercises as well as combined exhalation and inhalation exercises can help to improve pulmonary function<sup>10)</sup>. A previous study has suggested that visual feedback may also play a role in increasing respiratory muscle activity and pulmonary function<sup>11)</sup>. Many studies on breathing effects and improvements to respiratory function have been conducted, but no studies have been performed on the differences between breathing with mainly expiration and breathing with mainly inspiration. Thus, this study aimed to determine the effects of breathing with mainly expiration or inspiration on pulmonary

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function and changes in chest expansion while breathing, and to provide a foundation for determining which intervention method is suitable for use in lung disease patients on a one-to-one basis.

## SUBJECTS AND METHODS

The subjects of this study were 20 healthy male university students who were informed about the objectives and methods of the study in detail and gave voluntary consent to participate in the experiment. Subjects who had experienced neurological disorders or severe musculoskeletal disease, had the cold, or had smoked more than 10 cigarettes a day were excluded. The general characteristics of the subjects are shown in Table 1. The participants were provided with a written informed consent form in accordance with the ethical standards of the Declaration of Helsinki.

This study was designed to determine the effects on pulmonary function and chest expansion values (CEVs) in breathing with mainly inspiration group (BMIG) and breathing with mainly expiration group (BMEG). The subjects were randomly divided into two groups and the BMIG performed a 15-minute breathing exercise five times a week up to the inspiratory reserve volume (IRV), while the BMEG did a 15-minute breathing exercise five times a week up to the expiratory reserve volume (ERV). The protocol for the breathing exercises was planned without the need for any devices. The subjects were trained how to breathe up to the IRV or ERV by a cardiopulmonary professor. After 2 minutes of either type of breathing, the subjects rested for 1 minute. Thus, a total of five sets were performed. Both groups performed their exercise for four weeks, and re-education was provided once a week to remind them how to breathe. If the subjects felt dizziness or discomfort during the exercise, it was stopped immediately.

A Cardio Touch 3000S (BIONET, Korea) was used to measure vital lung capacity during pulmonary function examination. The subjects were seated on a chair in an upright position during the examination to reduce compensation of the trunk and improve safety. To measure vital lung capacity, forced vital capacity (FVC), forced expiratory volume in one second ( $FEV_1$ ),  $FEV_1/FVC$ , and peak expiratory flow (PEF) were measured three times and the highest values were used.

A tape measure was used to measure chest size after the subjects had removed their shirts, and a single examiner measured all subjects to reduce rater error. All measurements were performed in the upright sitting position. Chest size during inspiration (CSI) and chest size during expiration (CSE) were measured in order to record the CEV based on the spinous process at the tenth thoracic vertebra and the xiphoid process of the sternum<sup>12</sup>.

The Kolmogorov-Smirnov test was performed with the measured values to verify normalization. To compare the results of both groups before and after the experiment, a paired t-test was conducted. To compare the differences between both groups before and after the experiment, an independent t-test was conducted. The significance level was set at  $p < 0.05$  and SPSS ver. 18 software was used for statistical processing.

## RESULTS

After 4 weeks, the BMIG showed no significant differences in CSE and  $FEV_1/FVC$ , but did demonstrate significant differences in CSI, CEV, FVC,  $FEV_1$ , and PEF. The BMEG showed no significant difference in CSI, but did display significant differences in all of the other variables measured.

A comparison of the results between the groups before exercise showed no significant differences, whereas the BMEG demonstrated significant differences from the BMIG in CSE, CEV, and PEF after exercise. A comparison of the changes in variables between the groups showed no significant differences in CSI or  $FEV_1$ , whereas the BMEG demonstrated significantly different changes in CSE, CEV,  $FEV_1/FVC$ , and PEF while the BMIG demonstrated a significantly different change in FVC ( $p < 0.05$ ) (Table 2).

## DISCUSSION

The respiratory muscles, which play an important role in pulmonary function, do not only show improvements in muscle strength and endurance if they are trained in the same manner as skeletal muscles<sup>13</sup>, but can also improve maximal inspiratory pressure, maximal expiratory pressure, and pulmonary function<sup>14</sup>. The current study aimed to measure and verify any changes in chest and pulmonary functions when breathing with mainly inspiration or expiration was performed, and to

**Table 1.** General characteristics of the subjects (mean  $\pm$  SD, n = 20)

Characteristic	BMIG (n = 10)	BMEG (n = 10)
Age (years)	25.6 $\pm$ 1.7	26.0 $\pm$ 2.4
Height (cm)	176.6 $\pm$ 4.4	174.9 $\pm$ 4.5
Weight (kg)	73.0 $\pm$ 5.1	73.0 $\pm$ 6.0

BMIG: breathing with mainly inspiration group; BMEG: breathing with mainly expiration group

propose a suitable intervention and exercise method for patients with lung disease.

A comparison of the results in the BMIG and BMEG before and after exercise showed that the BMIG demonstrated significant differences in CSI, CEV, FVC, and PEF. The results of a study of 10-week inspiration muscle exercises in patients with multiple sclerosis also showed a similar result, with increased FVC and PEF<sup>15</sup>. In another study, breathing with mainly inspiration contracted not only the diaphragm, which is an inspiratory muscle, but also the inspiratory accessory muscles, such as the sternocleidomastoid, scalenus, trapezius, pectoralis major, pectoralis minor, and serratus anterior, thereby expanding the chest<sup>16</sup>. In our study, the BMEG showed no significant difference in CSI, but did display significant differences in the other variables measured, because breathing with mainly expiration contracts the rectus abdominis, transversus abdominis, obliques, and internal intercostals<sup>17</sup>.

There were no significant differences between the groups prior to the experiment, but changes in the measured variables after the experiment showed that the BMEG displayed significantly different increases in CSE, CEV, FEV<sub>1</sub>/FVC, and PEF, because breathing with mainly expiration activated abdominal muscles that are not used during normal breathing. In a previous study, pan flute blowing exercise was more effective for improving the abdominal muscles than a diaphragm exercise and pan flute blowing exercise<sup>18</sup>. Another study of inspiration and expiration breathing exercise methods that aimed to improve the pulmonary function of patients with cervical spinal cord injuries showed that the expiration exercise group had significantly higher pulmonary function in all evaluation indexes (except for FEV<sub>1</sub>/FVC) than the inspiration exercise group<sup>19</sup>. The present study showed more significant differences in the BMIG, which is likely to be related to increased chest wall expansion<sup>20, 21</sup>. It also showed that the change in FVC was significantly increased in the BMIG as compared to the BMEG, whereas the change in CEV was significantly decreased in the BMIG as compared to the BMEG. This is likely to be a result of the fact that the subjects used thoracic breathing habitually and then changed to abdominal breathing. CEVs were measured from the spinous process at the tenth thoracic vertebra and the xiphoid process of the sternum<sup>12</sup>. Therefore, only the size of the rib cage was measured. In previous studies, abdominal breathing has been shown to increase FVC<sup>22, 23</sup>, thoracic cage limitation, and deformation of the diaphragm<sup>24</sup>. A typical characteristic of patients with chronic obstructive pulmonary disease (COPD) is low FEV<sub>1</sub>, which aggravates quality of life and is an important criterion of lung injuries<sup>25</sup>. Thus, issues with pulmonary function or chest limitation in patients should be resolved as soon as possible, and we propose that if a suitable intervention method is applied according to our study results, treatment will be more efficient.

This study has the following limitations. It was not a controlled experiment, and the observed findings could have been affected by confounding factors such as motivation, the experimental setting and procedure, and the investigator's conduct. In a future study, patients with poor pulmonary function will be studied and changes in their pulmonary function and chest expansion will be investigated according to the breathing methods described here.

**Table 2.** Comparison of changes in chest expansion and pulmonary function between the groups (mean ± SD)

Variable	Group	Pre-test	Post-test
CSI (cm)	BMIG	90.6±5.3	92.7*±5.9*
	BMEG	94.9±7.0	96.0±6.8
CSE (cm)	BMIG	83.7±5.5	83.91±5.92
	BMEG	88.7±7.2	85.3±6.9* <sup>a</sup>
CEV (cm)	BMIG	6.9±1.6	8.8±1.4*
	BMEG	6.2±1.6	10.60±1.8* <sup>a</sup>
FVC (L)	BMIG	4.0±0.5	4.4±0.5*
	BMEG	4.1±0.6	4.3±0.6* <sup>a</sup>
FEV <sub>1</sub> (L)	BMIG	3.4±0.4	3.7±0.3*
	BMEG	3.4±0.5	3.8±0.6*
FEV <sub>1</sub> /FVC * 100 (%)	BMIG	85.9±6.2	84.9±5.9
	BMEG	84.6±4.1	89.6±5.1* <sup>a</sup>
PEF (L/s)	BMIG	5.9±1.8	7.1±1.6*
	BMEG	6.6±1.8	9.0±1.1* <sup>a</sup>

\*Significant difference from pre-test  $p < 0.05$ ; <sup>a</sup>Significant difference in change between the two groups  $p < 0.05$

CSI: chest size during inspiration, CSE: chest size during expiration, CEV: chest expansion value, FVC: forced expiratory vital capacity, FEV<sub>1</sub>: forced expiratory volume in one second, FEV<sub>1</sub>/FVC: FEV<sub>1</sub> as a percentage of FVC, PEF: peak expiratory flow

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