Original Article

Effect of the trunk forward bending angle in sitting position on slow vital capacity

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Abstract. [Purpose] The purpose of this study was to examine whether a trunk forward bending angle in sitting position affected slow vital capacity (SVC). [Subjects and Methods] The subjects of this study were 18 healthy college students to whom the study’s methods and purpose were explained and their agreement for participation was obtained. Slow vital capacity was measured using spirometry (Pony FX, COSMED Inc., Italy), repeatedly at a body bending angle of 0°, 15°, and 30° in the sitting position. [Results] Vital capacity, expiratory reserve volume, and inspiratory reserve volume were significantly different according to the trunk forward bending angle. There were no statistically significant differences in tidal volume and inspiratory capacity. [Conclusion] The results demonstrated that the body bending angle of 15° in the sitting position was the most effective angle for increasing lung volume. Key words: Trunk forward bending angle, Sitting position, Slow vital capacity

(This article was submitted Aug. 26, 2017, and was accepted Sep. 29, 2017)

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a respiratory disease with restrictive airflow, and is classified as a lung inflammatory disease.1 With a mortality rate of 4, COPD is one of the most serious diseases worldwide. The prevalence of COPD in Korea is 18% among persons over 45 years of age2. In general, Chronic Obstructive Pulmonary Disease (COPD) is unlikely to be cured once it develops, and causes damage to various body tissues as well as the respiratory system3. As a result, patients with COPD often have a lowered health-related quality of life4. In general, patients with COPD exhibit an abnormal breathing pattern of Hoover’s sign in which the thoracic breathing pattern is visible during inspiration, and the flattened diaphragm is drawn into the rib cage5. Garcia-Pachon and Padilla-Navas6) investigated the incidence of Hoover’s sign in 157 COPD patients and their association with dyspnea. As a result, 45% of all COPD patients and 76% of very severe COPD patients displayed Hoover’s sign. As such, Hoover’s sign and dyspnea were highly correlated in the abovementioned studies.

O’Neill & McCarthy7) reported that a trunk forward bending posture in sitting position was effective in alleviating dyspnea and in increasing maximal inspiratory pressure (MIP) in COPD patients displaying Hoover’s sign. Willeput and Sergysels8) reported that the length-tension relationship of the diaphragm and the mechanical coupling of the rib cage were improved in the trunk forward bending position. This body forward bending with arm-bracing position has been reported to relieve dyspnea and expiratory flow limitation of COPD patients, and to increase lung capacity and muscle strength of the respiratory muscles7, 9, 10).

However, although there are studies on the arm-bracing position that relieves dyspnea while leaning against the arm, there is a lack of research on the specific body angle that can relieve dyspnea most effectively. Thus, the purpose of this study is to investigate how the lung capacity changes according to the trunk forward bending angle in sitting position with

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an arm-bracing position.

SUBJECTS AND METHODS

The subjects were 18 college students (10 males, 8 females) in Busan. All subjects fully understood the purpose and methods of the study, which complied with the ethical standards of the Declaration of Helsinki. Written informed consent was obtained from each participant. To avoid all factors that may affect the pulmonary function test, all subjects were asked to cease smoking 1 hour before, cease drinking alcohol 4 hours before, avoid overeating 2 hours before, and refrain from excessive exercise 30 minutes before the measurements were taken. The mean age of the subjects was 23.2 ± 1.9 years, mean height was 169.4 ± 8.5 cm, and mean body weight was 63.6 ± 11.0 kg. The lung function measurement tool used in this study was digital spirometry (Pony Fx, COSMED, Italy). Slow vital capacity (SVC) was measured. The angles of trunk bending based on the vertical line of ground were 0°, 15°, and 30°. The angles were selected after preliminary examination in various angles of trunk bending on sitting position. It was difficult to deep breathing in over 30 degree of trunk bending. So the angles, 0°, 15°, and 30°, were selected. Angles were measured using a digital inclinometer (DUALER IQ Inclinometer, JTech Medical, USA). One unit of the digital inclinometer was placed on first sacral vertebra and the other unit was placed on the lateral midline of the femur. The neck was maintained in a straight line with a digital inclinometer (Cervical Inclinometer, Jtech Medical, USA). To obtain chest and abdominal circumference measurements, a tape measure was used. In an upright sitting position, the chest circumference was measured based on the xiphoid process and the abdominal circumference was measured based on the umbilicus during maximal inspiration and expiration. At this time, the chest breathing pattern was determined by comparing the difference between the maximum inspiration and the maximum respiration perimeters. Slow vital capacity was measured repeatedly at a body bending angle of 0°, 15°, and 30° in the sitting position. The nose was closed using nasal forceps, the elbow joints were fixed to the table, the measurement tool was held with both hands, and the mouthpiece was bitten. Measurements were performed starting with quiet breathing, and then followed by maximal exhalation and maximal inhalation according to the instructions provided with the measuring instrument. Sufficient time was allowed to return to normal breathing status between measurements11). The mean value of 3 measurements in the pulmonary function test was used for the analysis. The repeated measurement ANOVA test was performed to evaluate the change in lung capacity according to the bending angle of the trunk. In addition, LSD in the main effect test was performed to observe the difference in the amount of change according to angle. The statistical program used in this study was SPSSWIN (ver. 23.0) and the significance level was α=0.05.

RESULTS

Vital capacity (VC) differed significantly according to the angle of the trunk in the arm-bracing position (p<0.05). The main effect test result was higher at 15° than at 0° and 30°. Expiratory reserve volume (ERV) also was significantly different according to the angle of trunk bending in the arm-bracing position (p<0.05). The main effect test result was higher at 15° than at 0° and 30°. The inspiratory reserve volume (IRV) also was significantly different according to the angle of trunk bending in the arm-bracing position (p<0.05). The main effect test result was higher at 0° than at 30°. On the other hand, there was no difference between 0° and 15°, or between 15° and 30°. There was no statistically significant difference in case of tidal volume (Vt) and inspiratory capacity (IC) (Table 1).

Table 1. The effect of sitting posture angle leaning forward with arm bracing on the slow lung capacity (Unit: l)

| Variables | 0°       | 15°      | 30°      |
|-----------|----------|----------|----------|
| VC*†      | 3.2 ± 0.8 | 3.3 ± 0.9 | 3.1 ± 0.8 |
| ERV*†     | 1.5 ± 0.4 | 1.7 ± 0.5 | 1.6 ± 0.4 |
| IRV*‡     | 1.1 ± 0.5 | 1.0 ± 0.5 | 0.9 ± 0.5 |
| Vt        | 0.6 ± 0.3 | 0.6 ± 0.3 | 0.7 ± 0.3 |
| IC        | 1.7 ± 0.5 | 1.6 ± 0.5 | 1.5 ± 0.5 |

* Mean ± SD.
† p<0.05 by repeated ANOVA.
‡ 15°>0°, 15°>30° and 0°=30° by Least Square Difference (LSD).
VC: Vital capacity; ERV: Expiratory reserve volume; IRV: Inspiratory reserve volume; VE: Expiratory minute ventilation; Vt: tidal volume; IC: Inspiratory capacity.
DISCUSSION

Ogino et al.\(^1\) reported that the most comfortable posture for COPD patients was a forward bending posture of 28.4°. They compared the differences in pulmonary functions of COPD patients in each of the standing position, trunk forward bending position, and trunk forward bending with arm-bracing position. As a result, it was reported that end-inspiratory lung volume (EILV) and end-expiratory lung volume (EELV) were improved significantly in the trunk forward bending with arm-bracing position, and expiratory flow limitation was alleviated in that position. In addition, Cavalheri et al.\(^6\) measured and compared maximal inspiratory pressure (MIP), maximal expiratory pressure (MEP), and maximal voluntary pressure (MVV) in a trunk forward bending at 30° with the arm-bracing on standing position in the COPD patients. As a result, it was confirmed that the MIP, MEP and MVV in that position were higher than those of the standing position. In other words, the trunk forward bending with arm-bracing position can be helpful in heightening vital capacity by increasing inspiratory and expiratory pressures.

Kera & Maruyama\(^2\) measured the vital capacity in sitting with an elbow on the knee position (SEK), in supine position, in sitting position, and in standing position. As a result, it was found that the vital capacity and ERV were higher in the SEK positions. In addition, they reported high muscle activation of external oblique abdominis during expiration in SEK position. External oblique abdominis originates from the 5th to 12th ribs and attaches to iliac crest and linea alba to increase pressure on the thoracic and abdominal cavities. Therefore, it can be concluded that the SEK position increases the contractile capacity of the external oblique abdominis to increase the expiratory lung capacity, and thus the total lung capacity. However, research on the most effective body bending angle is currently insufficient. Thus, the purpose of this study was to investigate the difference in vital capacity at various body angles, and to find out the most effective body bending angle that can increase lung capacity. The body flexion angles were 0°, 15°, and 30° in sitting with the elbow on the knee position (SEK). Checking slow vital capacity changes in each posture, it was confirmed that the vital capacity (VC) was the highest at 15°. Also, the expiratory reserve volume (ERV) was highest at the body bending angle of 15°. On the other hand, the inspiratory reserve volume (IRV) was higher at the body bending angle of 0° than at 30°. However, there was no statistically significant difference between body bending angles of 0° and 15° and between 15° and 30°. Tidal volume (VT) and inspiratory capacity (IC) did not change significantly according to the body bending angle. Generally, the vital capacity (VC) is the combined volume of the tidal volume (VT), the inspiratory reserve volume (IRV), and the expiratory reserve volume (ERV). In the study, there was no difference in the tidal volume (VT) according to the body bending angle, and the inspiratory reserve volume (IRV) was not significantly different between 0° and 15°. On the other hand, the expiratory reserve volume (ERV) was the highest at the body bending angle of 15°. Therefore, the factor that has the greatest effect on the increase of vital capacity in the SEK position is the expiratory reserve volume (ERV). These results are similar to those of Kera & Maruyama\(^2\). In this study, it was demonstrated that VC and ERV are higher when the trunk is bent 15° forward in SEK position due to the external oblique abdominis being most activated at this angle.

This study therefore demonstrated that the body bending angle of 15° in the sitting position was the most effective angle for increasing lung volume. However, since this study was intended for normal adults, it is difficult to apply to COPD patients. Therefore, it is necessary to study the most effective bending angle of the body by experimenting with individual patients who suffer from COPD. It is also necessary to research the effect of external oblique abdominis on lung capacity by comparing the change in lung capacity according to the body bending angle and the change in the muscle activity of the related muscles at the same time. In addition, the previous researchers reported that the change in vital capacity (VC) was greatest at 28.4° and 30° of the frontal bending angle of the body, but it was the highest at 15° in this study. These different results could be due to the measurement zone. The body bending angle in this study was formed in the first sacral vertebra and the midline of the femur, but the angle in previous studies was formed in the midline of the femur and the lateral line of the body. Therefore, further studies should be conducted in the future to suggest the correct criteria for body bending angle.

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