A Study of the Influence of the Pulmonary Function on the Angles of Thoracic Kyphosis and Lumbar Lordosis in Community-Dwelling Elderly Women

JUN HORIE, MSc, PT,1,3), SHIN MURATA, PhD, PT1), YOSHINORI INOUE, PT2), SADAAKI NAKAMURA, PT2), YUICHI MAEDA, PT2), YOSHIHI MATSUMOTO, PT2), TAKAHIKO SANNOMIYA, MD2), ETSUO HORIKAWA, PhD3)

1)Department of Rehabilitation Sciences, Nishikyushu-University: Kanzaki-machi Ozaki 4490–9, Kanzaki City, Saga 842-8585, Japan.
TEL: +81 952-52-4191, FAX: +81 952-51-4481, E-mail: horiej@nisikyu-u.ac.jp
2)Department of Rehabilitation Sannomiya Orthopedic Clinic
3)Center for Comprehensive and Community Medicine, Graduate School of Medicine, Saga University

Abstract. [Purpose] The purpose of this research was to investigate the impact of vertebral column alignment on respiratory function in elderly female subjects. [Subjects] The subjects were 23 female community-dwelling elderly (age: 76.8 ± 5.1 years old, BMI: 23.6 ± 2.3). [Methods] The thoracic kyphosis angle was determined by adding the angles of the superior and inferior vertebral bodies from the 1st to the 12th thoracic vertebrae, and the lumbar lordosis angle was determined by adding the angles of the superior and inferior vertebral bodies from the 1st to the 5th lumbar vertebrae. For evaluation of respiratory function, flow volume was measured with determination of forced vital capacity (FVC), % forced vital capacity (%FVC), one second forced expiratory volume (FEV1.0), and one second forced expiratory volume rate (FEV1.0%). [Results] No significant correlation was found with any respiratory parameter for the thoracic kyphosis angle, but the lumbar lordosis angle showed a significant correlation with FVC, %FVC, and FEV1.0. [Conclusion] For impacts of vertebral column alignment on respiratory function the lumbar lordosis angle may be more important than the thoracic kyphosis angle.

Key words: Respiratory function, Lumbar lordosis angle, Thoracic kyphosis angle

INTRODUCTION

Vertebral column alignment is evaluated to determine causes of dysfunction and disability in the assessment of exercise ability of patients with respiratory failure. In the vertebral column, thoracic vertebrae form the joint of the rib head and the costotransverse joint of the rib cage, and thus are considered to affect expansivity of the rib cage. Lumbar vertebrae also have a large effect on respiratory movement because the body and rib head process form part of the attachment site of the diaphragm, the main muscle in respiratory movement. The lumbar vertebrae also border the thoracic and peritoneal cavities1).

Recent studies have shown a correlation between respiratory function and muscle force of patients with kyphoscoliosis due to osteoporosis, and many
reports have suggested the importance of vertebral column alignment\(^2\)\(^-\)\(^14\). Although the subjects of most of these studies had no organic problems in the respiratory system, the results suggest that deformity of the spine may affect respiratory function and muscle force. Therefore, to determine levels of dysfunction and disability, it is important to evaluate vertebral column alignment in patients with COPD and other chronic respiratory failure diseases that are associated with possible spine deformity due to the advance of age, since a complication of spinal deformity may be a key factor that defines the severity of these diseases. Examinations of deformity of the spine have been performed in clinical evaluations of patients with respiratory failure, but detailed and objective evaluations have not been conducted in most cases. Therefore, we think that deformity of the spine has tended to be disregarded in the evaluation of such patients.

We examined the impact of vertebral column alignment on respiratory function in female elderly subjects, in a preliminary study of patients with chronic respiratory failure. The subjects were classified into groups based on vertebral column alignment using the thoracic kyphosis angle and lumbar lordosis angle to obtain data for future research into respiratory failure. We hope to use the results of this study to examine the importance of evaluation of vertebral column alignment and as a basis for clinical treatment.

**SUBJECTS AND METHODS**

**Subjects**

The subjects were 23 female community-dwelling elderly who received an explanation of the objectives of the study and provided their informed consent. The mean age (± standard deviation) of the subjects was 76.8 ± 5.1 years old and the mean body mass index (BMI) was 23.6 ± 2.3 (height: 149.1 ± 5.4 cm, weight: 52.7 ± 6.3 kg). None of the subjects had respiratory failure, circulatory diseases, or severe cognitive deficit. None had certification of need for long-term care, and all were able to perform activities of daily life (ADL) by themselves using an automobile, bicycle, or on foot.

**Methods**

For evaluation of vertebral column alignment, the subject was placed in a resting standing position with a broad base (hip width). Measurement of the thoracic kyphosis and lumbar lordosis angles were done with a spinal shape analyzer (Spinal Mouse, Index), a computer-aided measuring device, which measures sagittal spinal inter-segmental angles in a non-invasive way. The accuracy of the Spinal Mouse has already been proven by Post RB, et al.\(^{15}\) and Mannion AF, et al.\(^{16}\). The Spinal Mouse is run paravertebrally along the spinal column from the 7th cervical vertebra to the 3rd sacral vertebra. The thoracic kyphosis angle is determined by adding the angles of the superior and inferior vertebral bodies from the 1st to the 12th thoracic vertebrae, and the lumbar lordosis angle is determined by adding the angles of the superior and inferior vertebral bodies from the 1st to the 5th lumbar vertebrae (Fig. 1). Measurement of vertebral column alignment was performed 3 times and the average values were used.

For evaluation of respiratory function, flow volume was measured using an SP-300 electronic spirometer (Fukuda Denshi), with determination of forced vital capacity (FVC), % forced vital capacity (%FVC), one second forced expiratory volume (FEV\(_{1.0}\)), and one second forced expiratory volume rate (FEV\(_{1.0}\)%).

Pearson's correlation analysis was performed to examine the correlation of respiratory function parameters (FVC, %FVC, FEV\(_{1.0}\), and FEV\(_{1.0}\)% with the thoracic kyphosis angle and the lumbar lordosis angle. Data were analyzed using SPSS version 16J for Windows and with a significance level of less than 5%. Data are shown as mean values ± standard deviation.
RESULTS

The evaluation of respiratory function gave values of FVC, %FVC, FEV\textsubscript{1.0}, and FEV\textsubscript{1.0}% of 1.66 ± 0.39 L, 78.4 ± 16.1%, 1.41 ± 0.34 L, and 85.3 ± 9.8%, respectively. The thoracic kyphosis and lumbar lordosis angles were 40.2 ± 12.7 ° and –8.7 ± 10.4 °, respectively (Table 1). No significant correlation was found with any respiratory parameter for the thoracic kyphosis angle, but the lumbar lordosis angle showed a significant correlation with FVC, %FVC, and FEV\textsubscript{1.0} (Table 2).

DISCUSSION

Thoracic vertebrae form the joint of the rib head and the costotransverse joint of the rib, thereby constituting a part of the rib cage, and the movability of these joints is low. This may explain our observation of an absence of a correlation of the thoracic kyphosis angle with markers of respiratory function, since the impact of the thoracic kyphosis angle on the movability of the rib cage may be small. In addition, the trapezius muscle (transverse and ascending fibers) controls breathing in which thoracic vertebrae are involved, but this muscle is an accessory muscle of inspiration that does not have a large impact on thoracic expansion, suggesting that the strength of this muscle may not be reflected in respiratory function.

Lumbar vertebrae are not part of the rib cage, unlike thoracic vertebrae, but are associated with a part of the diaphragm that expands the rib cage in inspiration. This part of the diaphragm is attached to the body of the lumbar vertebrae and rib head process. Thus, it is likely that the lumbar lordosis angle may have an impact on respiratory function. Decreases in FVC and %FVC were seen with an increase in the lordosis angle and they may have occurred due to expansion of the lumbar region of the diaphragm in relation to the increase in lumbar lordosis angle, leading to decreased constriction efficiency of the diaphragm and inhibition of expansion of the lower rib cage. Pushing up of the diaphragm by increased celiac inner pressure due to the increased lumbar lordosis angle may also have reduced the constriction efficiency of the diaphragm and affected FVC and %FVC. Thus, synergistic effects may cause inhibition of expansion of the lower rib cage. Teramoto et al.\textsuperscript{5,14} and Leech et al.\textsuperscript{8} have reported that intraoral pressure (Pimax) is decreased by backward curvature, and Lisboa et al.\textsuperscript{11} suggested that the diaphragmatic muscle force (Pdi) and Pimax at maximal inspiration are lower in patients with respiratory failure than in healthy persons. A correlation between deformity of the spine and a decrease in endurance of the respiratory muscle has also been suggested\textsuperscript{13}). The function of the diaphragm is an important factor in the correlation between deformity of the spine and respiratory function, and our results confirm that deformity of the lumbar vertebrae, which are associated with part of the diaphragm, is related to markers of respiratory function.

Regarding the correlation between deformity of the spine and emphysematous changes, backward curvature is thought to extend the occipitofrontal diameter of the upper rib cage and enlarge the retrosternal space, resulting in acceleration of emphysematous changes in the anterior basal segment (S8) and lung lobe located in the intrathoracic frontal region. Some reports have suggested that FEV\textsubscript{1.0} may be decreased by backward curvature\textsuperscript{3,5,7,9,10} and this study also

| Table 1. Characteristics of the subjects |
| N  | 23 |
| Sex | Female |
| Age (yrs) | 76.8 ± 5.1 |
| BMI | 23.6 ± 2.3 |
| Height (cm) | 149.1 ± 5.4 |
| Weight (kg) | 52.7 ± 6.3 |
| FVC (Litter) | 1.66 ± 0.39 |
| %FVC (%) | 78.4 ± 16.1 |
| FEV\textsubscript{1.0} (Litter) | 1.41 ± 0.34 |
| FEV\textsubscript{1.0} /FVC (%) | 85.3 ± 9.8 |
| Thoracic kyphosis angle (°) | 40.2 ± 12.7 |
| Lumbar lordosis angle (°) | –8.7 ± 10.4 |

FVC: Forced Vital Capacity, %FVC: FVC/FVC pred, FEV\textsubscript{1.0}: One Second Forced Expiratory Volume, FEV\textsubscript{1.0}%: FEV\textsubscript{1.0}/FVC. Values are given as the mean ± SD.

| Table 2. Pearson product-moment correlation coefficient of each parameter |
|---------------------------|---|---|---|---|
|                          | FVC | %FVC | FEV\textsubscript{1.0} | FEV\textsubscript{1.0}% |
| TKA                      | 0.02 | 0.14 | 0.00 | –0.06 |
| LLA                      | –0.65*** | –0.63*** | –0.50* | 0.31 |

TKA: Thoracic Kyphosis Angle, LLA: Lumbar Lordosis Angle, %FVC: FVC/FVC pred, FEV\textsubscript{1.0}%, FEV\textsubscript{1.0}/FVC, ***p<0.01, *p<0.05. |
showed a significant correlation between lumbar lordosis angle and FEV$_{1.0}$. We found no significant correlation with FEV$_{1.0\%}$, but this requires further examination with an increased number of cases.

Many previous studies have suggested that deformity of the spine is associated with respiratory function, and especially with FVC and %FVC. In this context, our results indicate that evaluation of vertebral column alignment using the lumbar lordosis angle is more useful than evaluation of the thoracic kyphosis angle. It has also been suggested that the impact of deformity of the spine on respiratory function is not reflected in the QOL of healthy elderly persons$^9$), but deformity of the spine, and especially of lumbar vertebrae, might have a large impact on respiratory function and prognosis for patients with respiratory failure, with large effects on ADL and QOL. The reasons include the deformity of the spine, presence of pulmonary organic lesion and dyspnea. In this regard, we believe that evaluation and treatment of vertebral column alignment in patients with respiratory failure are of importance. Therefore, it will be necessary to examine the correlation of vertebral column alignment with respiratory function, respiratory muscle force, motor ability, ADL, and QOL in future studies.

REFERENCES