

# Analysis of the pulmonary functions of normal adults according to pillow height

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**Abstract.** [Purpose] The purpose of this study is to examine changes in pulmonary functions in relation to the sleeping positions of the experimental subjects. [Subjects and Methods] The subjects for this study were twenty randomly selected males and females from K University. Measurements were taken in the supine position at three different pillow heights: 0 cm, 5 cm, and 10 cm. Pulmonary functions (vital capacity, tidal volume, inspiratory reserve volume, and expiratory reserve volume) were evaluated using a Fit mate. [Results] These findings suggest that a pillow height of 5 cm makes a significant difference in vital capacity (VC). When the three pillow heights were compared, significant differences were seen between 0 cm and 5 cm, and between 5 cm and 10 cm, in terms of vital capacity for the pulmonary functions among the three positions. [Conclusion] In conclusion, changing the positions of the subjects produces changes in pulmonary functions. The greatest change occurred in the 5 cm pillow height. Presumably, ventilation is affected by the body structures. The results will provide objective data to establish the most suitable positions for stroke patients when they perform respiratory exercises.

**Key words:** Pulmonary function, Pillow, Height

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## INTRODUCTION

Humans spend roughly one-third of their lives sleeping. Sufficient sleep helps reinvigorate the body and mind, while insufficient sleep causes fatigue and disturbs our daily lives. Lack of sleep causes symptoms like being in daze throughout the day, low levels of concentration, and slower speeds in performing tasks<sup>1)</sup>. Therefore, restful sleep is essential for humans to live quality lives and to enhance their health.

While sleep is affected by internal physical factors, it is also affected by external factors, such as bedrooms, pillows, and beds. In particular, research reports that pillow height and size is closely related to quality sleep<sup>2)</sup>. In a reclining position, pillows of appropriate height support the body and head in a stable and natural condition, facilitating various bodily movements that occur during sleep. However, when people use pillows of inappropriate height, blood circulation in the neck is hindered, thereby increasing the risk of neurological disorders, such as cerebral hemorrhage. The use of an ill-suited pillow during the long hours of sleep can be counterproductive to rest and recovery from fatigue, the purpose of sleep. Indeed, it may actually increase fatigue<sup>1)</sup>. Reiterer et al.<sup>3)</sup> reported that hyperflexion in the cervical spine in a

reclined position can block the flow of air. Meanwhile, Beni Solow et al.<sup>4)</sup> noted that increased cervical region height can inhibit the in-flow of air by hindering the process of securing the airway. Ultimately, the height of the pillow is a major factor influencing lung capacity.

A number of studies have investigated the respiratory function of normal individuals in a supine position. For example, Townsend<sup>5)</sup> stated that a reclining position causes blood congestion in the pulmonary blood vessels as abdominal organs pressure the diaphragm toward the head and the venous return increases; in this situation, lung volumes are relatively reduced. Allen et al.<sup>6)</sup> reported that in a reclining position, the amount of blood in systemic circulation, which moves to pulmonary circulation, increases. This scenario decreases the volume of the thorax, and abdominal contents press the diaphragm, leading to labored breathing. As a result, the overall pulmonary function is reduced. Morgan et al.<sup>7)</sup> noted that a reclining position weakens back muscles, which subsequently reduces lung capacity. In addition, Song et al.<sup>8)</sup> and Hong et al.<sup>9)</sup> reported that normal individuals in a lying position showed an overall larger increase in lung capacity than those in a standing position. In terms of respiratory competence in a lying position, this finding indicates that pulmonary function is reduced due to changes in physical structures and the effects of gravity.

Through this body of research, it becomes clear that a number of studies have focused on lung capacity according to postural changes in a lying position, but few have considered lung capacity according to pillow height. Therefore, this study aimed to obtain concrete and objective data on changes in lung capacity according to pillow height.

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## SUBJECTS AND METHODS

The study subjects were 20 university students attending N University in Cheonan, Chungnam. The subjects were selected from among those who had no particular history of lung diseases, had no accompanying damage, such as congenital deformation of the chest, and had not received any particular treatment to improve pulmonary functions.

The subjects understood the purpose of this study and consented to participate in it. This study was approved by the International Review Board of the Korea Nazarene University and was conducted in accordance with the ethical principles of the Declaration of Helsinki. The general characteristics of both groups are shown in Table 1.

In this study, the subjects lay down on a bed within a treatment room maintained at an average temperature of 20 °C. They relaxed in order to encourage expansion of the thorax and movement of the abdominal walls. In addition, a curtain was drawn over the subjects to help them maintain psychological stability. The subjects straightened out their legs on the bed and kept their head and trunk straight. After they rested for 15 to 20 minutes in the supine position without a pillow, their pulmonary function was measured. After this process, the height of the pillow was changed. The subjects first lay on a pillow that was 5 cm high and then on a pillow that was 10 cm high.

If a subject complained of fatigue or dizziness during respiration measurement, a break was taken and the exercise resumed some time later. Prior to the measurement, the tester taught each subject the proper method for respiration measurement 2 or 3 times in order to ensure that the subject was comfortable performing it.

Pulmonary function of the participants was measured in a sitting position using a tool called Fitmate (COSMED, Sri, Italy). To ensure accurate measurements, the tester explained and demonstrated the exercise to each subject beforehand. Both the experimental and control groups were instructed to use the mouthpiece and to block the nostrils during the measurement so that air was neither inhaled nor exhaled through the nose. Starting from exhalation, subjects slowly exhaled to maximum level following the tester's signal and then slowly inhaled; tidal volume (TV), inspiratory reserve volume (IRV), expiratory reserve volume (ERV), inspiratory capacity (IC), and volume capacity (VC) were measured at this time<sup>10, 11</sup>.

Data was analyzed using the SPSS Version 12.0 program for Windows. To compare and analyze chest mobility and pulmonary function in relation to position, one-way analysis of variance (ANOVA) was performed. For post-analysis, to show differences among positions, Fisher's least significant difference (LSD) test was used. The statistical significance level,  $\alpha$ , was chosen as 0.05.

## RESULTS

Here we review the comparison of pulmonary function during maximal inspiration according to changes of position in pillow height. The experimental group showed significant differences and VC ( $p < 0.05$ ); however, it did not show any significant difference in TV, ERV, and IRV ( $p > 0.05$ ). In the

**Table 1.** General participant characteristics

	Subjects (n = 20)
Age (years)	21.7 ± 1.1
Height (cm)	171.7 ± 5.4
Weight (kg)	65.5 ± 4.4

Values are means ± SD

**Table 2.** Comparison of the Pulmonary function measurement in the 20s subjects according to pillow height changes of position

	position		
	0 cm	5 cm	10 cm
TV (L)	0.4 ± 0.2	0.6 ± 0.2	0.5 ± 0.2
VC (L) <sup>a*</sup>	5.1 ± 1.5	5.3 ± 1.6	4.9 ± 1.5
IRV (L)	3.5 ± 1.5	3.3 ± 1.7	3.2 ± 1.5
ERV (L)	1.1 ± 0.6	1.5 ± 0.7	1.0 ± 0.8

Mean ± SE

\*Significant difference from pre-test value,  $p < 0.05$

<sup>a</sup> significant difference in gains between the two groups,  $p < 0.05$

VC of differences between before and after the experiment, significant differences were found for between 0 cm and 5 cm, and between 5 cm and 10 cm ( $p < 0.05$ ), but not for TV, IRV, and IC ( $p > 0.05$ ) (Table 2).

## DISCUSSION

Adequate sleep and pulmonary function are necessary for humans to maintain quality lives. Meanwhile, bedding is a factor that affects sleep. Lung capacity is a fundamental measure in evaluating respiratory function and can result in different values according to postures. Therefore, it is essential to compare differences in changes in lung capacity according to postural changes in order to accurately evaluate respiratory function<sup>12</sup>.

This study examined the effects of pillow height on the lung capacity of 20 normal individuals, male and female university students in their twenties. Based on the research, humans feel comfortable psychologically with pillows that are 4 to 10 cm high<sup>13</sup>. This study employed pillows with heights of 0 cm, 5 cm, and 10 cm for subjects in a supine position. By measuring pulmonary function, this study intended to examine changes in vital capacity (VC), tidal volume (TV), inspiratory reserve volume (IRV), and expiratory reserve volume (ERV). Each variable for lung capacity was measured three times for each subject, and the maximum value was adopted based upon the standards developed by many previous studies<sup>6</sup>. The results of the measurements showed statistically significant differences in VC between 0 cm and 5 cm, and between 0 cm and 10 cm. The highest VC was found at the 5 cm height. However, statistically significant differences were not observed in TV, IRV, and ERV. This finding may indicate that high pillows excessively

bend the curvature in the normal cervical region, which reduces the airway space through which air flows into the laryngopharynx; this structural change reduces the capacity for ventilation.

Previous studies also showed a number of cases in which the pulmonary function of normal individuals was reduced in a reclining position. This body of research indicates that, along with the vertical effects of gravity, the limited airway due to cervical curvature reduced respiratory function<sup>14</sup>. Beni Solow et al.<sup>4</sup>) reported that increases in the height of the cervical region hamper the inflow of air by hindering the process of securing the airway. Another study considered the respiratory mechanism of premature babies, finding that excessive curves in the cervical region hinder the inflow of air by reducing the airway<sup>3</sup>).

The current study seems to exhibit results similar to those of other studies regarding the pulmonary function of normal individuals. Therefore, based on the results of the present study, using pillows of appropriate height for patients who stay in bed for long hours or patients with cardiopulmonary diseases is likely to contribute to their stable respiratory function. Future studies are required to directly evaluate the respiratory functions of patients who stay in bed for long hours due to impaired mobility or patients with cardiopulmonary disorders, thereby providing an accurate analysis of their respiratory functions.

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