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Measurement of Changes in Chest Mobility and Pulmonary Functions in Relation to Stroke Patients' Positions

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Abstract. [Purpose] The purpose of this research was to study the changes in chest mobility and pulmonary functions in relation to stroke patients' situation. [Methods] Twenty stroke patients participated in this experiment. Measurements were taken in the supine position, 45° sitting position leaning against a surface, and 90° sitting positions, in a random order. Chest mobility (during rest, during maximal inspiration, and during maximal expiration) in each position was evaluated using a tape measure, and pulmonary functions (vital capacity, inspiratory capacity, tidal volume, inspiratory reserve volume, expiratory reserve volume) were evaluated using a spirometer. [Results] The results show a significant differences in chest circumference during maximal inspiration for chest mobility between supine and sitting at 90°, and significant differences in tidal volume and vital capacity for the pulmonary functions among the three positions. [Conclusion] In conclusion, changing a stroke patient's position produce changes in chest mobility and pulmonary functions. The greatest change occurred in the 90° sitting position. Presumably, ventilation is affected by gravity, The results will provide objective data for establishing stroke positions for stroke patients performing respiratory exercises.
Key words: Stroke, Chest mobility, Pulmonary function, Position

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INTRODUCTION

Stroke causes brain damage because of a blockage of blood supply to the brain tissues, due to obstruction of blood flow in the blood vessels, causing impairment in motor functions and sensory functions and seriously impairing physical activities[1]. In addition, long periods of bed rest after the onset of stoke result in multiple complications of cardiopulmonary function, nutrition metabolism, and secretory function[2]. Since cardiopulmonary function impairment is directly connected to life conservation, it is important to evaluate patients functional capacity through accurate pulmonary function measurements[3].

Disuse of muscles and limited activity due to stroke cause cardiopulmonary weakness and lack of oxygen[4]. In addition, a decrease in chest motion and electrical activity become evident on the paratic side[5]. Because of declines in cardiopulmonary functions, pulmonary elasticity decreases, along with respiratory volume and capacity. In addition, the decline of chest wall flexibility decreases the elasticity of the respiratory muscles and the sensitivity of the respiratory center[6]. Furthermore, walking becomes more energy-intensive compared to normal walking, and the increase in energy consumption decreases exercise endurance and increases fatigue[4].

Positions affect respiratory muscle activity by changing the length of the respiratory muscles during rest[7] and inducing changes in ventilation and perfusion, in particular, the maximum air exchange that occurs depends on gravity[8]. In our review of previous studies of respiratory functions in relation to position, we found that studies have been conducted on normal subjects[9, 10], cerebral palsy patients[11], and spinal cord injury patients[12, 13]. However, objective data on changes in the chest mobility and pulmonary function of stroke patients in relation to changes in position are scarce. This study aimed to find the positions in which stroke patients can utilize their best respiratory capacity by comparison and analysis of chest mobility and pulmonary function changes in relation to position.

SUBJECTS AND METHODS

The subjects of this study were 20 chronic stroke patients who had been diagnosed with stroke by computed tomography or magnetic resonance imaging (MRI), with a duration of at least six months after the onset of their stroke. The subjects understood the purpose of this study and agreed to participation in it.

The subjects of the study were selected from among patients without any particular history of respiratory disease before the onset of stroke, and without combined injury such as congenital chest deformity, rib fracture, or history of treatment to increase pulmonary function. A further criterion for inclusion was that all subjects had to score 24 points or higher on the Mini-Mental State Examination/Korean version (MMSE-K) to ensure that they were able to understand and follow the researcher's orders.

The general characteristics of the research subjects are summarized in Table 1. Of the 20 patients, 12 were male and 8 were female. Their average age was 63.1±8.7, their average height was 164.7±10.7 cm, and their average weight was 63.4±9.6 kg. Regarding the affected sides, 8 had right-side hemiplegia, and 12 had left-side hemiplegia. The average time since the onset of stroke was 17.8±5.4 months. The physical and functional abilities of the subjects are summarized in Table 2. Their average heart rate was 74.4±11.9 bpm, and their average systolic and diastolic blood pressures were 124.6±14.1 mmHg and 78.7±10.3 mmHg, respectively. Their average score on the Berg Balance Scale was 40.0±9.7 and that of the Functional Ambulation Category was 3.6±0.5. Their time in for the Timed Up and Go Test was 27.1±10.1 seconds, and their average score on the Baithel Index was 75.4±5.6.

The subjects' chest mobility and pulmonary function were measured in the supine position while lying on an adjustable table with the legs stretched straight out and the head and trunk maintained in a straight line, in a sitting position leaning against a 45° surface, and in a sitting position at 90°. A research assistant helped the patient maintain the positions, if the patient was unable to do so by himself/herself. The measuring positions were selected in a random order, and the measurements were taken twice for each position; the average value was calculated for the analysis. The patients were allowed to rest for 3 minutes after each measurement to avoid fatigue.

To measure the degree of chest change while breathing, a tape measure was used to measure chest mobility. This method is considered reliable (ICC $_{0.81–0.91}$) and is widely used in clinics[14, 15]. All of the measurements in this study were taken by the same physical therapist who had 10 years of experience. The measurement were taken at the location that horizontally passes the junction between the xiphoid process and the body of the sternum[14]. Chest mobility was measured during rest with stable respiration, during maximal inspiration, when the patient inhaled had as much air as possible, and during maximal expiration when the patient had as much air as possible exhaled[16]. A CardioTouch 3000S (Bionet, USA) was used as the measuring equipment for the pulmonary function test. Before measuring pulmonary function, the patient was asked to wear a nose clip to prevent nose breathing. The patient then was instructed to put on a mouthpiece and breathe three to five times in the usual manner. While doing so, and upon hearing the starting signal from the respiratory equipment, the patient was directed to slowly exhale and inhale as much air as possible. The measurement was completed after another two or three regular and complete breaths. For accuracy, the measurements at each position were taken after the researcher had given the patient a thorough explanation and demonstrated the methods of measuring pulmonary function. In each of the three different positions, tidal volume (TV), vital capacity (VC), inspiratory reserve volume (IRV), expiratory reserve volume (ERV), and inspiratory capacity (IC) were measured.

Table 1. General characteristics of subjects

	Subjects (n=20)
Sex (male/female)	12/8
Age (years)	63.1 ± 8.7
Height (cm)	164.7 ± 10.7
Weight (kg)	63.4 ± 9.6
Paretic side (right/left)	8/12
Onset duration (months)	17.8 ± 5.4

Values are Mean ± SD

Table 2. Characteristics of physical and functional abilities

	Subjects (n=20)
Heart rate (bpm)	74.4 ± 11.9
Blood pressure (mmHg)	
Systolic blood pressure	124.6 ± 14.1
Diastolic blood pressure	78.7 ± 10.3
Berg balance scale (score)	40.0 ± 9.7
Functional ambulation category (score)	3.6 ± 0.5
Timed up and go (sec)	27.1 ± 10.1
Baithel index (score)	75.4 ± 5.6

Values are Mean ± SD

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, α, was chosen as 0.05.

RESULTS

The stroke patients in this study showed significant chest mobility changes during maximal inspiration in relation to their position. In particular, sitting in the 90° position showed significant changes compared to the supine position ($p<0.05$) (Table 3). For pulmonary function, the patients showed significant differences in TV and VC among all three positions, supine, sitting while leaning against a 45° surface, and sitting at 90°($p<0.05$) (Table 4).

DISCUSSION

This study measured whether there were changes in chest mobility and pulmonary function in relation to the position of stroke patients.

When chest mobility was compared among the three different positions, significant difference was found in chest mobility during maximal inspiration: compared to the supine position, the chest circumference showed a significant increase in the 90° sitting position.

Table 3. Chest mobility according to position

	Position		
	Supine position	Sitting position leaning against a 45° surface	Sitting position at 90°
Rest (cm)	94.0 ± 4.1	94.7 ± 4.1	94.7 ± 5.5
Maximal inspiration (cm)*	95.2 ± 1.2	95.7 ± 1.7	97.3 ± 1.7[a]
Maximal expiration (cm)	94.2 ± 1.4	94.0 ± 1.3	93.2 ± 1.7

Values are Mean ± SE, *$p<0.05$, [a] significant difference between supine position and sitting position at 90°

Table 4. Pulmonary function measurement according to position

	Position		
	Supine position	Sitting position leaning against a 45° surface	Sitting position at 90°
TV (L)*	0.5 ± 0.2	0.6 ± 0.2	0.9 ± 0.3 [abc]
IC (L)	2.7 ± 1.1	3.4 ± 1.2	4.3 ± 1.5
VC (L)*	3.1 ± 1.2	4.0 ± 1.3	5.4 ± 1.9[abc]
IRV (L)	1.5 ± 0.5	1.9 ± 0.6	2.5 ± 1.0
ERV (L)	0.9 ± 0.5	1.4 ± 0.6	1.9 ± 0.7

Values are Mean ± SE, *$p<0.05$, [a] significant difference between supine position and sitting position at 90°, [b] significant difference between supine position and sitting position leaning against a 45° surface, [c] significant difference between sitting position leaning against a 45° surface and sitting position at 90°

In previous studies conducted on healthy adults, the conjugate diameter of the chest wall decreased and the transverse diameter increased in sitting positions leaning against something, and the conjugate diameter of the chest wall appeared to be in the normal range in vertical positions[17)]. In addition, for patients with respiratory difficulties, chest mobility was greater increased more in sitting positions than in supine positions[18)]. In amyotrophic lateralsclerosis patients, the amount of general circulating blood moving into pulmonary circulation increases in supine position; reducing the volume of gas inspiration in the chest, and the abdominal contents pressing the diaphragm cause difficulty in air inspiration[19)]. Gravity hinders diaphragm movement in supine positions, and the air inhalation level decreases in the chest because it disturbs thorax dilatation. This supports the idea that chest mobility change is more effective in sitting positions than in lying positions.

In this research, when the pulmonary functions were compared among the positions differences, significant differences were apparent for VC and TV. VC and TV showed increases, in the following order, supine position, sitting while leaning against a 45° surface, and the 90° sitting position, and the increases was significant.

In a previous studies, it was reported that VC was different in different positions. In particular, when affected by gravity, changes in VC were substantial in relation to the positional changes[20)]. For normal subjects, VC decreased by 7.5±5.7% in supine positions compared to vertical positions[21)], and it increased significantly in sitting positions compared to supine positions[22)]. In addition, when subjects were raised vertically to 90° the abdominal wall was extended due to gravity, and functional residual capacity and respiratory capacity increased[23)]. Large differences of 29.0±20.6% in VC were reported between sitting positions and supine positions in amyotrophic lateral sclerosis patients[24)]. Among quadriplegic patients, VC decreased in supine positions and increased in vertical positions[25)]. In this study, similar to the results of previous studies, increases in vital capacity were seen in the sitting position; therefore, we believe sitting positions are believed to be the best positions for stroke patients to increasing the respiratory capacity of stroke patients.

As explained above, positional changes in stroke patients produce changes in chest mobility and pulmonary function. Gravity affects respiration in the supine positions. Due to added abdominal pressure, the lung space is pressed and the intraperitoneal organs lean toward the head of the diaphragm, disturbing air inspiration and causing changes in chest mobility and pulmonary function. Accordingly, sitting positions should be more helpful for patients to improve respiratory function. Through this data, the importance of setting uniform positions in clinical evaluations of the respiratory functions of stroke patients in the future is emphasized.

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