Antero-Posterior Excursion of the Hemithorax in Hemiplegia

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Abstract. Using a measuring caliper, 30 persons with residual hemiplegia and 30 healthy aged persons underwent measurement of antero-posterior excursion of the right and left hemithoraces during volitional deep breathing. There was no difference in the antero-posterior excursion of the sound hemithorax of the persons with hemiplegia, but the affected hemithorax showed significantly smaller excursions with crosswise differences in a range of 0 to 2.5 cm. In one third of the healthy aged persons the crosswise differences of antero-posterior excursion of the hemithoraces ranged from 0 to 1.0 cm. These findings suggest that the movement of the hemiplegic hemithorax becomes restricted following a cerebrovascular accident, and physiotherapists should be aware of the possibility of compromised respiratory function and postural disturbance when treating such persons.

Key words: Deep breathing, Hemithorax, Hemiplegia.

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INTRODUCTION

It is a known biological fact that respiratory function declines with age. In the case of hemiplegics respiratory function may be further compromised as cerebrovascular accident (CVA) tends to occur in the aged as well as involving paralysis of the ventilatory muscles.

Reports concerning the respiratory function of hemiplegics by lung volume measurements and röntgenographic readings can be found in the literature1–5). During tidal breathing of hemiplegics, according to Akashi1), there is a decrease in excursion of the paralyzed upper hemithorax by approximately 15% compared to that of the sound side, while the excursion of the lower hemithoraces remains symmetrical. During volitional deep breathing the excursion of the paralyzed upper and lower hemithoraces decreases by 15% and 10%, respectively, whereas, during spontaneous deep breathing or a sigh, the excursion of the paralyzed upper and lower hemithoraces remains symmetrical5). Further, Nakamura2) found that there is no difference in the excursion of the right and left hemithoraces during tidal breathing, while there is a considerable restriction of the chest excursion of the hemiplegic hemithorax during volitional breathing. Also, during forced expiration, the excursion of the hemiplegic hemithorax is limited, and there may be reversal of motion at the end-expiratory phase; that is, the hemiplegic hemithorax behaves paradoxically5). A case in point is when the hemiplegic hemithorax moves paradoxically during Valsalva and/or Müller manoeuvres5).

In comparison to the above, Oda and his associates3) reported in their analysis of lung...
volumes, that the effect of CVA is reflected more on expiratory muscle performance, especially that of the intercostal muscles. They also stated that the per cent volume of vital capacity increases with recovery from paralysis measured using the Brünstrom Recovery Stages.

The purpose of this study was to demonstrate the effect of paralysis and/or spasticity as a result of CVA on chest excursion by demonstrating the difference in antero-posterior (AP) excursion of both the sound and affected thoraces in persons with residual hemiplegia during volitional deep breathing.

**PARTICIPANTS AND METHOD**

*Selection of the participants*

Thirty persons with residual hemiplegia were chosen from two convalescent hospitals in the City of Kanazawa. Their mean (and standard deviation or SD) age was 67.9 (11.2) years old. These hemiplegics consisted of 15 males with a mean (SD) age of 66.3 (10.1) years and 15 females with a mean (SD) age of 65.5 (4.8) years. Out of these participants, 14 (7 males and 7 females) were right hemiplegics and 16 (8 males and 8 females) left hemiplegics. The selection criteria were as follows: the participants demonstrated no respiratory conditions; no apraxia, agnosia or dementia; independent gait with/without a stick; and he/she had not been bed-bound in the past three months.

Thirty healthy aged persons as the control population were chosen from a senior citizens’ home in the City of Kanazawa with a mean (SD) age of 67.1 (12.1) years. These participants consisted of 15 males with a mean age of 61.0 (11.1) years and 15 females with a mean age of 73.1 (5.0) years.

*Instrument*

The measurement tool was a caliper, a Martin-type human body measuring device. It is comprised of a compass and two curved arms with a scale at the joint and is used for measuring firm objects and thickness of fatty tissue.

*Measurement procedure*

Following preliminary measurements using one female and five male college students, the measurement points on the thorax and position of the participants were decided. The anterior measurement point was determined to be at the junction where the fifth and sixth costal cartilages merged on the anterior aspect of the thorax (× marks in Fig. 1). The horizontal distance from this point to the anterior midline of the body, which roughly corresponds with the xiphoid process, varied from person to person because of their physique, so the distance for the anterior measurement points was calculated as $a$ centimetres (cm) to the right and $b$ cm to the left of the anterior midline. Next, a point on the posterior midline of the body corresponding with the thoracic spinal process and on a level with the anterior measurement point was selected as the posterior measurement point. The posterior measurement point on each participant’s thorax was determined by being $a$ cm away to the right and $b$ cm away to the left of the posterior midline.

The participants, with their upper body exposed and seated on a chair, had both upper limbs relaxed by their sides. The tip of each arm of the caliper was placed on each respective × mark anteriorly and posteriorly. The tips of the caliper arms were firmly held by the examiner’s hands so that the caliper did not deviate during rib movement. The participant was instructed to concentrate his/her attention to the area where the caliper was placed. The examiner read the scale on the caliper and recorded the readings following the verbal commands below:

- “Breathe out as slowly and deeply as possible” (deep expiration).
- “Next, breathe in as slowly and deeply as possible” (deep inspiration).
- “Now, breathe out as slowly and deeply as possible” (deep expiration).

The amount of chest excursion was measured in centimetres (cm) with an increment of 0.5 cm. The AP excursion of each hemithorax was calculated using the following formula:

$$\text{Chest excursion} = \beta - \text{lesser of } \alpha \text{ or } \gamma$$

Where

- $\alpha = \text{AP movement of the hemithorax in deep expiration}$
- $\beta = \text{AP movement of the hemithorax in deep inspiration}$
- $\gamma = \text{AP movement of the hemithorax in deep expiration}$

Each hemiplegic participant was randomly assigned a number, and the ones with odd numbers
were measured on the sound side of the thorax first and those with even numbers from the paralyzed side. The healthy aged participants were measured from the left thorax first and then the right thorax. Each hemithorax was alternately measured three times for all participants. The highest of the three measurements was taken as the AP excursion of the hemithorax. The actual procedure was carried out by one investigator (KO) to prevent inter-tester variability in the measurement. The ambient room temperature was maintained at 28 degrees Celsius during the measurement. Data collection for each participant in the hemiplegic group took place during one testing session, and also for the healthy aged group but on a different day. The procedures and risks of the study were explained to the participants before the measurement took place, and their written informed consent was obtained.

**Data Analysis**

The following three factors were examined: the difference in the AP excursion of the hemithorax between healthy and hemiplegic participants; the difference between the sexes; and the crosswise difference in the AP excursion of the hemithorax of healthy and hemiplegic participants. Student’s t test was used for all statistical calculations with the statistical significance at 0.05.

**RESULTS**

The mean (SD) AP excursion of the sound hemithorax in hemiplegic males was 2.40 (0.48) cm, and the affected hemithorax 1.23 (0.55) cm. In hemiplegic females, the mean (SD) AP excursion of the sound hemithorax was 2.33 (0.65) cm, and the affected hemithorax 1.27 (0.65) cm (Table 1). There was a statistically significant difference in the AP excursion between the sound and affected hemithoraces of both the males and females (p<0.01). One hemiplegic male participant showed a larger AP excursion of the affected hemithorax

<table>
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<tr>
<th>Chest excursion (cm)</th>
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<tbody>
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<td></td>
<td>male</td>
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<tr>
<td></td>
<td>Sound side</td>
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during deep expiration than for deep inspiration.

In the healthy males, the mean (SD) AP excursion of the right hemithorax was 2.53 (0.74) cm, the left 2.60 (0.76) cm. In the healthy females, the mean (SD) AP excursion of the right and left hemithoraces was 1.80 (0.44) cm, respectively (Table 2). The AP excursion of both the right and left hemithoraces of the males was significantly larger than that for the females (p<0.05).

A comparison between the healthy and hemiplegic participants revealed that the mean AP excursion of the right and left hemithoraces of healthy males and the mean AP excursion of the sound hemithorax of both male and female hemiplegic participants were almost equal.

There were crosswise differences in AP excursion of the hemithoraces in one third of the healthy aged participants of up to 1.0 cm, but two thirds demonstrated no crosswise difference (Table 3). The mean (SD) crosswise difference in AP excursion of the hemithoraces of healthy participants was 0.2 (0.19) cm.

There were 0 to 2.5 cm crosswise differences in the hemiplegic participants. However, over half of them were within a range of 1.0 to 1.5 cm (Table 3). The mean (SD) crosswise difference in AP excursion of the hemithoraces of the hemiplegic participants was 1.18 (0.45) cm. The crosswise difference in the hemiplegic participants was larger than that of the healthy aged participants.

**DISCUSSION**

Hardly any crosswise difference was observed in this study among the healthy aged participants, which was expected. Further, the fact that the AP excursion of both the right and left hemithoraces of the healthy aged males was significantly larger than that of the healthy aged females can be explained by the obvious biological differences in their physique. The healthy females, however, demonstrated a significantly small AP excursion of the hemithoraces. This may be due to the fact that the healthy females were older in age than the other groups in this study; there was, in fact, an eight-year difference. However, according to analysis of lung volumes of the aged, the per cent volume of vital capacity decreases with age without any statistical significance, with females showing slightly higher volumes, but again, without statistical significance. Further study will be needed to clarify why a smaller excursion of the thorax occurred in the healthy aged females.

In both hemiplegic males and females the AP
excursion of the affected hemithorax was only about 50% of that of the sound side. This may have been brought about by paralysis of the hemithorax. Nakamura\(^2\) has reported that, in hemiplegics, the excursion of the thorax during tidal breathing is equal on both the sound and affected sides, and that the amount of excursion is equal to that of healthy persons. Nakamura\(^2\) also speculated that respiratory function may be mediated through the cerebral cortex if, as is the traditional belief, the medulla oblongata and pons which house the respiratory center cannot be isolated for either the right or left side of the body. Inokuchi and his associates\(^5\) also advocated a similar idea. In addition, it is possible that the sound hemithorax may increase in volume after the CVA to compensate for the loss of movement on the affected side. This may contribute to a further problem of postural disturbance caused by scoliotic change in the thorax, hence asymmetry of the upper body. In fact, during the measurement procedure, while procuring a detailed frontal observation of the hemiplegics it was revealed that they had a very slight scoliotic-like change in their upper body. This fact suggests that they had become asymmetrical breathers as a result of CVA.

In both male and female hemiplegics both the sound and affected thoraces demonstrated an almost equal amount of excursion. This finding contradicts the significant difference demonstrated in healthy male and female chest excursion. This may have been brought about by the over-compensation of the sound hemithorax in the hemiplegic females.

From the above findings, we speculate that exercise tolerance of hemiplegics may be decreased. Therefore, physiotherapists should pay attention to improving excursion of the affected thorax, though a certain amount of over-compensation by the sound hemithorax will be inevitable depending on the severity of hemiplegia.

This study examined chest excursion of the hemiplegic thorax with a simple measuring device and a procedure which can easily be duplicated in a clinical situation for a quick thoracic assessment. Possible benefits from this study would be that, with this simple method of measurement, the physiotherapist may easily observe anatomical changes in physical features of chest excursion of hemiplegic individuals. It would also serve as an assessment tool by its calculation method of informing us of whether or not hemithorax movement improves as muscle paralysis recovers.

The movement as we know of the thorax is three-dimensional. Therefore, the limitation of this study was that it did not incorporate lateral and perpendicular excursions of the hemithoraces. These factors should be addressed in the future. Another potential limitation may have been the uncertainty of the intra-tester reliability of hemithorax excursion measurements, although the intra-tester reliability of the chest girth has been well established\(^6\).

REFERENCES