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Chest excursion and breathing patterns in the aged

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ABSTRACT

Measurements of chest girth are commonly used to assess the physical effect of disease on chest motion. The purpose of the present study was to investigate any changes in breathing patterns of the aged and if there would be any difference in them between the sexes. We collected data on 24 elderly individuals and 30 college-age students. Chest excursion was operationally defined as the difference in chest girth between tidal inspiration and tidal expiration at two separate sites (axillary and xiphoid). A plastic tape measure was used to measure chest excursion in a seated position during tidal breathing. Using Student's *t* test the differences in chest excursion were calculated for both sites between those of the males and females and between the elderly and young adults. Also calculated and compared was the proportion of the upper chest movement to that of the whole between the males and females and between the elderly and young adults. The elderly males showed significantly larger excursions of the chest than the elderly females and young adult males ($p<0.01$, $p<0.001$). There was neither a sex nor age difference in the proportion of the upper chest movement to the whole, which was in a range of 43 % to 45 %. It could, therefore, be concluded from this evidence that, in light of decreased thoracic compliance in the elderly and lower ventilation/perfusion ratio in the dependent lung, cardiopulmonary physiotherapy interventions should aim for lower costal and/or diaphragmatic breathing patterns with consideration of the role of gravity on the effects of ventilation.

KEY WORDS

breathing pattern, chest excursion, axillary folds, xiphoid process, measurement

INTRODUCTION

Observation of people's breathing patterns reveals slight differences during volitional deep breathing. Male chest movement tends to concentrate in the region of lower costal/diaphragmatic and females the apical region. But there are differences of opinion ; Kapandji states that, in quiet or tidal breathing of normal adults, men's breathing patterns incorporate a combination of the upper and lower chest movement, whereas women's figure predominately in the upper chest[1]. Yet, according to Carlson[2], chest excursion at the xiphisternal level in volitional deep breathing of normal adult men and women does not differ significantly.

Harasawa[3] states that changes in breathing pattern due to ageing occur when compliance of both the thorax and lung decreases and the ventilatory muscles weaken, making elderly persons' breathing less efficient. In addition, the physiological ageing process of the respiratory system produces the so-called *aged lung* which is accompanied with decreased pulmonary function[4]. The incidence of aged lung increases to 55.4 % in 60-year-olds and to 78.3 % in 70-year-olds[5]. The aged lung may be related to and influ-

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enced by breathing patterns derived from chest motion or vice versa.

The purpose of the present study was to investigate whether any changes would occur in the elderly group's breathing patterns, and whether or not there would be any difference in them between the sexes. From the results of these findings, our understanding of certain aspects of mechanics of respiration in the elderly and young adult during tidal breathing would be further increased. In addition, these findings could be related to cardiopulmonary physiotherapy interventions. However, it was not possible to account for all factors in the present study, but it would be of interest to investigate them in future research projects.

PARTICIPANTS AND METHOD

Selection of the participants Ten healthy elderly males were selected with a mean (and standard deviation or SD) age of 71.4 (3.8) years and 14 healthy elderly females with a mean (SD) age of 72.6 (4.5) years. Some of the participants lived at home in the City of Kanazawa, Ishikawa Prefecture and others in one of the senior citizens' homes in the City of Oyabe, Toyama Prefecture, Japan. Also participating in the present study as a control group were healthy college students, 15 of which were male with a mean (SD) age of 20.6 (1.2) years and 15 females with a mean (SD) age of 20.2 (1.3) years. The participants demonstrated no past history of respiratory disease or injuries to the trunk and chest.

Measurement procedure The measurement tool was a five-metre plastic "Eslon" tape measure (Sekisui Inc., Japan). The participants, with their upper body exposed and seated on a chair, had both upper limbs relaxed by their sides when measurements were taken. The measurement of chest excursion was carried out at two sites ; namely, at the level of the axillary folds and xiphoid process. The level of the axillary folds reflects the apical breathing pattern and the xiphisternal level lower costal and/or diaphragmatic breathing patterns, respectively. The unit of the tape measurement was in millimetres (mm) with an increment of one mm. Specifically, the tape measure was placed around the participant's chest to sufficiently overlap so as to allow movement during measurement by the examiner, and the participant was instructed to relax and breathe normally. Chest excursion was measured alternately at both sites three times, and the mean value was calculated from these three readings to be the chest excursion for each participant. The highest readings were recorded on termination of tidal expiration (α), tidal inspiration (β), and, again, on tidal expiration (γ). The larger of either $\beta - \alpha$ or $\beta - \gamma$ was the recorded value. The actual procedure was carried out by one investigator (MC) to prevent inter-tester variability in the measurement[6,7], with the ambient room temperature kept at 25° to 28° Celsius during the procedure. The method and risks of the study were explained to the participants before the study took place, and a written informed consent was obtained.

Data analysis We calculated the difference in chest excursion at the two sites between the elderly males and females and between the young adults and elderly. A comparison was made to examine whether there would be a difference in the proportion of upper thoracic excursion to that of the whole thorax between the elderly males and females and between the elderly and young adults using the following formula :

$$\textit{Proportion of the upper chest movement (\%)} = \frac{a}{a+b}$$

Where

a = *amount of chest excursion at the level of the axillary folds*

b = *amount of chest excursion at the level of the xiphoid process*

Student's t test was employed for all the calculations with the level of significance at 0.01.

RESULTS

Mean (SD) chest excursions at both the axillary and xiphisternal levels of the elderly and young adult groups are shown in Figure. There was no significant difference in thoracic excursion between the young males and females at the two sites. However, the elderly males showed a significantly larger excursion than the elderly females at both sites ($p<0.01$).

As for the age difference, the elderly males showed a significantly larger excursion at both the axillary

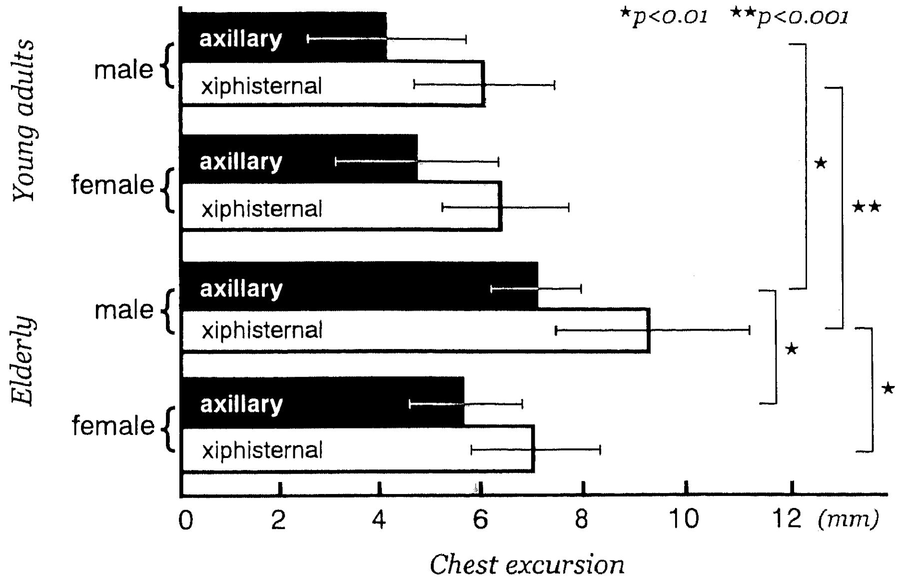

Fig. Chest excursion of the participants. Error bars denote one standard deviation.
■ : axillary level □ : xiphisternal level

level (p<0.01) and xiphisternal level (p<0.001) than that of the young adult males.

The mean (SD) proportion of the upper thoracic movement to that of the whole was as follows : 43.3 (2.83) % for the elderly males, and 44.4 (5.23) % for the elderly females, 45.4 (5.92) % for the young adult males, 41.4 (4.96) % for the young adult females, none of which showed either sex or age difference.

DISCUSSION

The findings from the present study are not in agreement with those of Kapandji's[1]. One of the reasons for this can be explained by the fact that Kapandji's statement probably deals with volitional and/or deep breathing[1], whereas ours deals with tidal breathing. Although the young adult females and elderly females showed no statistical difference in chest excursion at the axillary level, the latter's chest excursion tended to be larger. An explanation for this may be due to the past and possibly present-day life-style of elderly women tending to dress with kimono or the traditional Japanese attire, in which a wide belt is tightly wrapped around the lower chest and upper abdomen, restricting both lower thoracic and diaphragmatic excursion. Further, a similar effect on breathing patterns may result from wearing a corset which may restrict abdominal and lower chest excursion. Consequently, the breathing patterns of the elderly females become dominantly apical. Another factor for the difference in chest excursion of females compared to males may be the women's pulmonary physiological response to pregnancy and child birth. During the third trimester the diaphragmatic movement is inhibited by the growing foetus, changing the mechanical efficiency of the diaphragm. In addition, during the transitional stage of childbirth the mother is required to use apical breathing or panting so as not to 'push' until full dilatation of the cervix. Therefore, from these established facts, we can hypothesize that the dominant patterns of apical breathing in women seems to be firmly established in a motor engramme even during volitional deep breathing.

As one ages, changes in ventilation, diffusion capacity, and dynamics in the pulmonary circulation occur which reflects on the overall arterial blood gas composition[8]. Consequently, the partial pressure of oxygen falls rectilinearly with ageing. For instance, a 70-year-old's partial pressure of oxygen is 10 to 15 % lower than that of a 20-year-old. The most important contributing factor for the fall of the partial pressure of oxygen is closure of the peripheral airways of the dependent lung due to a decrease in elastic recoil which increases closing volume. Because of this the ventilation perfusion ratio of the pulmonary alveoli decreases in the dependent lung, and deflated alveoli are found to be increased in the elderly. According to Williams[9], such a condition with a mismatched ventilation/perfusion ratio is described as an insufficient process, so the individual must increase minute ventilation in order to compensate for the increased dead space. It seems that this fact could account for the increase in the chest excursion of the elderly males compared to that of the young males in this study. However, this hypothesis appears to be contradicted by the fact that chest excursion in the elderly females is significantly smaller than that of the males, and, similarly, for that also of the young adult females. A further explanation for this may be accounted for by the simple fact of a larger physique of males compared to females and that the elderly males may have taken an unintentional volitional deep breath because of their over-enthusiasm of wanting to have a larger chest circumference. Another explanation for the elderly females' smaller chest excursion may be attributed to the decrease in compliance of the thorax. Harasawa[8] states that kyphotic change in the vertebral column especially in elderly females due to their loss of the estrogen hormone results in osteoporosis and, consequently, a decrease in thoracic compliance with a relative increase in activity of the diaphragm taking place. Also, Hiraiwa's investigation demonstrated that kyphosis increases with age and found that it was present in more than half of the 80-year-old females[10]. The present study was limited in scope, so all factors influencing breathing patterns could not be taken into account, but the strong influence of spinal deformity, especially in aged females, should be considered in future investigations of breathing patterns of the elderly.

Another important factor not considered in the present study was smoking, and Fukuchi[11] states that smoking is an additional negative factor that acts in compliance with the ageing process and greatly influences the formation of an aged lung. Therefore, this would be an interesting factor to investigate in future studies of this kind.

Implications Humans are bipedal and upright-oriented animals, and since blood flow of the upper lung is generally hindered by gravity in the vertical position, the ventilation/perfusion ratio is higher in the upper lung field. On the contrary, in the lower lung, the blood flow is the most prevalent, and, therefore, the ventilation/perfusion ratio is low. Further, lung volume is lower in the dependent lung making it difficult to inflate and, consequently, has the vulnerability of a decrease in surfactant with resultant alveoli collapse. From these known physiological facts, we, as physiotherapists, must aim for large ventilatory movement of the lower chest which raises the ventilatory efficiency in the lower lung fields, so that efficiency of pulmonary gaseous interchange will be higher. Specifically, clients, bed-bound or at high-risk, should be taught lower costal and/or diaphragmatic breathing patterns. This, together with change of body position, especially sitting, would be especially important for the peri-operative care of thoracic conditions and post-thoracic/abdominal surgery. Therefore, any client in the aged group must be considered as high-risk when undergoing operative procedures especially if additional risk factors are present, eg. lung disease, thoracic deformity, immobility, etc.

References

1) Kapandji, I.A. : Physiology of the Joints III. 138-147, Churchill Livingstone, Edinburgh, 1974.
2) Carlson, B. : Normal chest excursion. Phys Ther 53 : 10-14, 1973.
3) Harasawa, M. : On aged lung. Respiration and Circulation 22 : 20, 1974. (in Japanese)
4) Harasawa, M. : Aged lung. Geriatric Clinic 4 : 1-5, 1983. (in Japanese)
5) Tanimoto, S. : Respiratory tract disease, Geriatric Clinic 2 : 17-22, 1981. (in Japanese)
6) Cook, A., et al. : Intertester and intratester reliability of chest excursion measurements in normal subjects. Cardiopul Phys Ther J 10 : 168, 1999.
7) LaPier, T.K., et al. : Intertester and intratester reliability of chest excursion measurements in subjects without impairment. Cardiopul Phys Ther J 11 : 94-98, 2000.
8) Harasawa, M. : Respiratory tract disease. Geriatric Clinic 1 : 33-37, 1980. (in Japanese)
9) Williams, A., et al. (Translated into Japanese by Murao, M.) : The lung. Ishiyaku Publications Inc., 1968.
10) Hiraiwa, H., et al. : Kyphosis in the aged (second report). J Jpn Surg Soc 57 : 454, 1956. (in Japanese)
11) Fukuchi, Y., et al. : Respiratory organs. Geriatric Clinic 4 : 35-40, 1983. (in Japanese)

高齢者の胸郭可動域と呼吸様式

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要　　旨

胸郭可動域の測定は胸部の疾病や傷害の影響を知るために用いられている。本研究では，ヒトの呼吸様式が老化に影響されるのか，また呼吸様式には性差があるのか否かについて検討した。対象は，高齢者24名（男性10名，女性14名，平均年齢72.0歳）で，対照群として健常大学生30名（男女15名ずつ，平均年齢20.4歳）が参加した。巻尺を腋窩と剣状突起の高さで当て，平静呼吸時の呼息時と吸息時の胸囲を測った。高齢男性では二つの高さともに高齢女性と若年男性に比べて胸囲が有意に大きかった。上部胸郭の動きの胸郭全体の動きに対する割合は，男女ともに，また高齢・若年者ともに43～45%であり，有意差は認められなかった。呼吸理学療法においては，下位肺の換気・血流比の低いこと，また高齢者においては胸郭コンプライアンスの低下に鑑み，呼吸様式として下胸呼吸や横隔膜呼吸を指導することが望ましい。