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CERTAIN MOVEMENTS MEASURED ON INSPIRATION-EXPIRATION CHEST RADIOGRAPHS CORRELATED WITH PULMONARY FUNCTION STUDIES

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One hundred and fourteen young healthy males were examined by chest radiographs taken on inspiration and expiration. The diaphragm movement was correlated with pulmonary function studies (VC and FEV_1). No relationship was shown between diaphragm movements and vital capacity. Healthy persons may move the diaphragm (mean) less than 3 cm while expiring over 5 litres of air.

The left hemidiaphragm may be occasionally higher than the right. Unequality in movement of the hemidiaphragms is common.

THE study of diaphragm movements and certain other measurements obtained from inspiratory – expiratory chest radiographs may be helpful in the evaluation of emphysema, chronic bronchitis and asthma. (Reid, 1967, Nairn *et al.*, 1969). One limitation in the interpretation of measurements in diseased patients is a lack of knowledge of the normal range of diaphragmatic movements in subjects with proved normal pulmonary function. Simon *et al.* (1969) studied the diaphragm movements in an unselected group of industrial workers mainly between the ages of 35 and 65 years. Some of these persons had some degree of airways obstruction. The authors therefore thought that it would be of value to study a younger group of persons, none of whom had evidence of airways obstruction. This paper presents values obtained from a series of healthy subjects who were examined by inspiration and expiration chest radiographs, and whose vital capacities and forced expiratory volumes (1 second) were also known.

MATERIAL AND METHOD

One hundred and fourteen males between the ages of 17 and 34 years (Table 1) were examined. Each man was undergoing a routine physical examination and had no cardio-pulmonary complaints nor past history of significant thoracic disease. Two chest radiographs of each subject were taken, one in deep inspiration and the other in full suspended expiration. Both were posterior-anterior radiographs made at 6 feet with the subject standing. The same technician performed the entire series, carefully instructing each person to take a deep breath in or out as required. The cassette tray and the patient did not move between exposures, so that the lower margin of the film was the same distance above the floor on inspiration and expiration. This technique allowed an accurate measurement for diaphragmatic movement, based upon the difference in the level of the

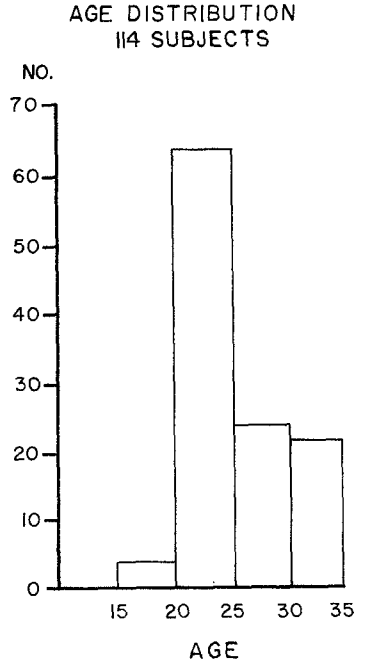

FIG. 1
Age incidence of the 114 healthy persons.

Work originated at: U.S.A.F. Hospital, Wiesbaden, Germany.

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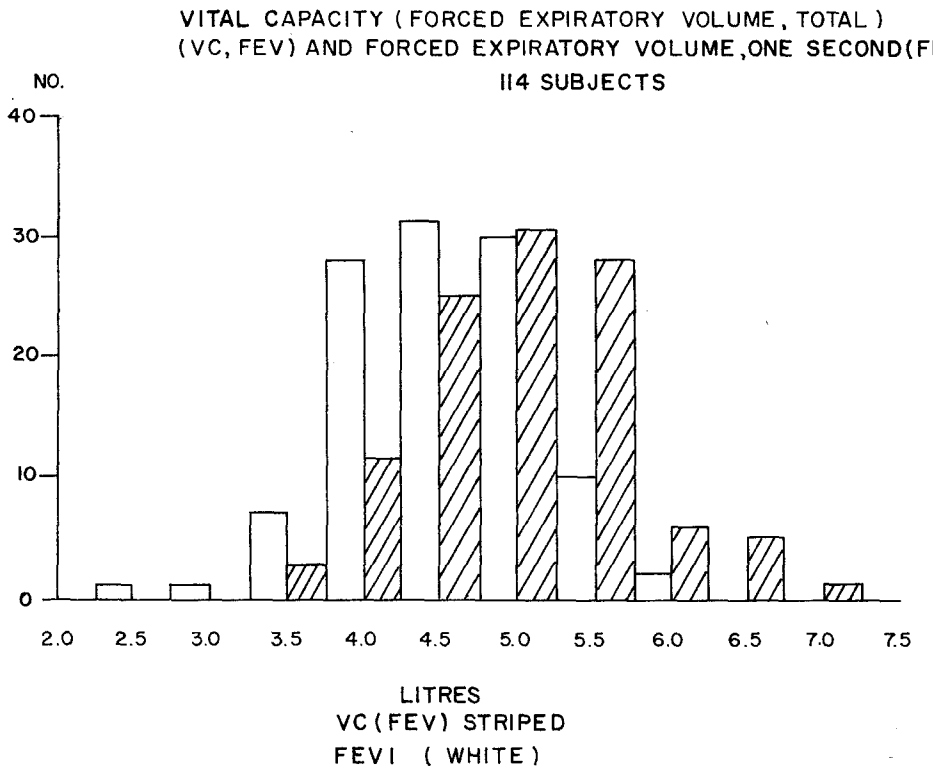

FIG. 2

Vital capacity (F.E.V.) and forced expiratory volume at 1 second (F.E.V.) of the 114 healthy persons.

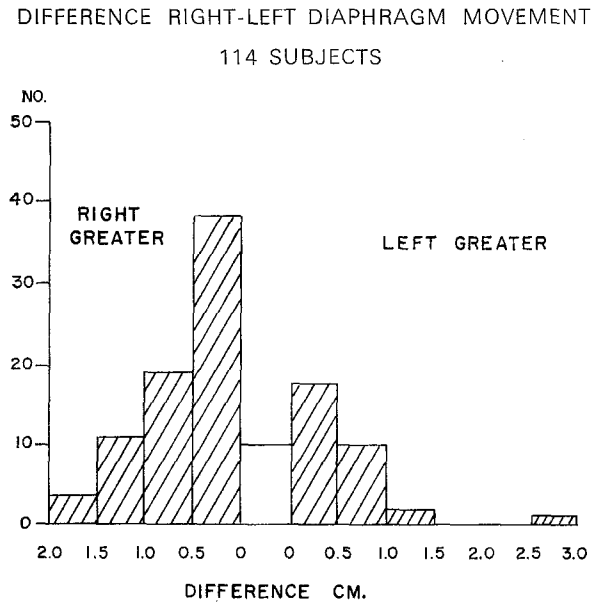

FIG. 3

Difference in range of movement between the right and left domes of the diaphragm on inspiration to expiration.

two domes measured from the bottom of the two films.

At the same time the forced expiratory volume (Vital Capacity) and the forced expiratory volume at 1 second (FEV_1) were measured on a standard spirometer, and the results are recorded in Table 2.

The FEV figures ranged from 3·5 litres to 7·1 litres. FEV_1 ranged from 2·4 to 6·0 litres. Only 2 persons had an FEV_1 below 3·0 litres. None of the subjects therefore had evidence of airways obstruction.

All distances were measured on each of the 2 radiographs. The measurements were:

1. Relative heights of the left and right domes in each radiograph. (114 subjects).

Three methods of measurement were used for each subject.

a. Height of the dome above the bottom of the film.
b. Distance from the upper margin of the first rib posteriorly to the dome.
c. Distance from the lower margin of the first rib anteriorly to the dome.

The figures from method (a) were used in the graphs, but the absolute values of method (b) were similar. Distances (c) were greater, as they are augmented by the lift of the sternum on inspiration.

RESULTS AND COMPARISON WITH PREVIOUS REPORTS

1. Inequality of movements of the diaphragm.

Unequal movement of the 2 domes was common. (Table 3). If a difference of 5 mm or less is considered equal, movement of 47 of the 114 persons demonstrated inequality. This corresponds to the findings of Alexander (1966) and Simon (1969). Thirty-four of the 47 moved the right diaphragm more than the left, but never with a greater difference than 1·9 cm. 13 of the 47 moved the left diaphragm more than the right, and in only one was the difference greater than 1·4 cm. The same material, expressed in differences measured to 1mm showed 10 movements equal, 73 greater on the right and 31 greater on the left. The greater movement of the right side is the opposite of the findings of Simon (1969) in an older age group. Alexander (1966) did not refer to age and also showed greater left movement.

The mean differences in these figures are expressed in Table 4. The 9 per cent equal movement is correct when differences are expressed by increments of 1 mm. The figures shown are similar to those in one of the earliest reported radiographic series, Dally (1908), who measured 15 subjects and found the right movements greater than the left by a mean difference of 2 mm.

2. Range of movement.

The mean diaphragm movements (Table 5) varied from 0·8 cm to 8·1 cm. 57 (50 per cent) of the subjects moved the diaphragm between 5 and 7 cm. 16 persons (14 per cent) moved their diaphragms less than 3 cm. This finding is important because it confirms the contention that small excursions are not necessarily abnormal or related to emphysema (Simon, 1969).

		Mean Difference
Equal	9%	0 cm.
Right+	64%	0·57 cm.
Left+	27%	0·48 cm.

Left more than 1 cm. in 3.
Right more than 1 cm. in 15.
Difference greater than 1.5 cm. 1 patient.

FIG. 4
Difference in range of movement of the right and left domes.

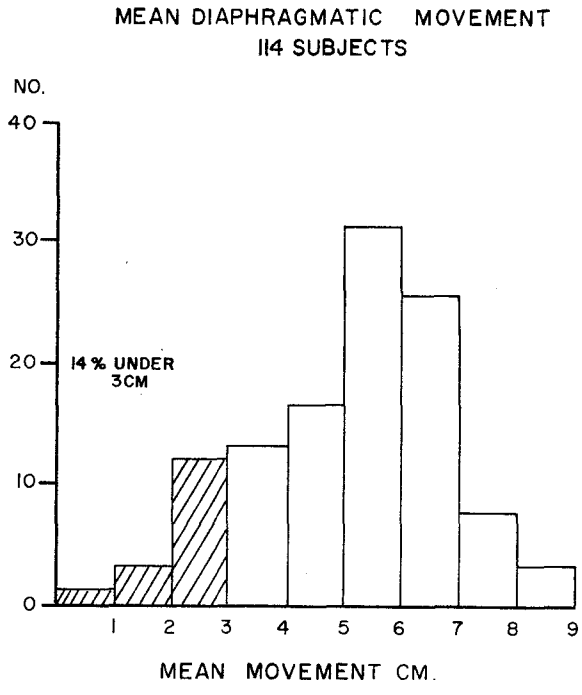

FIG. 5
Range of diaphragm movement from inspiration to expiration. Right and left domes divided by 2.

The mean movements corresponded well with those of Kalltreider *et al.* (1938), and with Wade and Gilson (1951): these studies were based upon 10 and 12 patients respectively, and did not demonstrate the wide range of normal movements shown in the graph.

The mean diaphragm movements were plotted against the Vital Capacity (Table 6). As the inspiration-expiration pair of radiographs are recorded at similar extremes of respiration to the vital capacity function test, one might expect a direct correlation in the 2 values. The dot graph shows no usable correlation between the 2 measurements. This agrees with the conclusion of Wade *et al.* (1954) who measured, simultaneously, radiographic movements of the diaphragm, changes in chest circumference and the volume of ventilated air.

Such a finding is not unexpected. No doubt if synchronous PA and lateral views had been taken, there would have been a closer relationship between the area or volume measurements from the radiographs and the amount of air expired. All that this present paper indicates is that the amount of diaphragm movement as seen in the PA view does not reflect the patient's ability to expire a large volume of air.

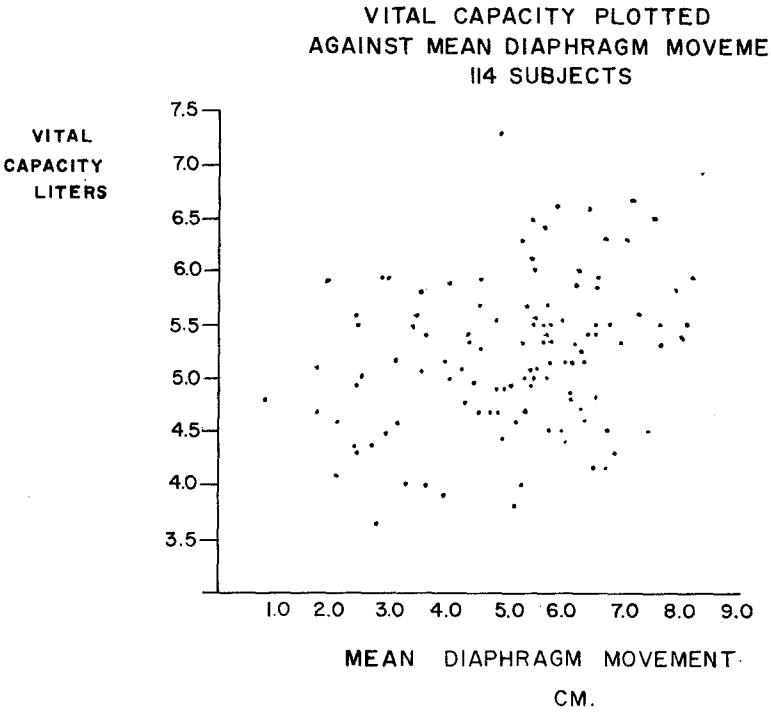

FIG. 6

Relation of vital capacity to diaphragm movement.

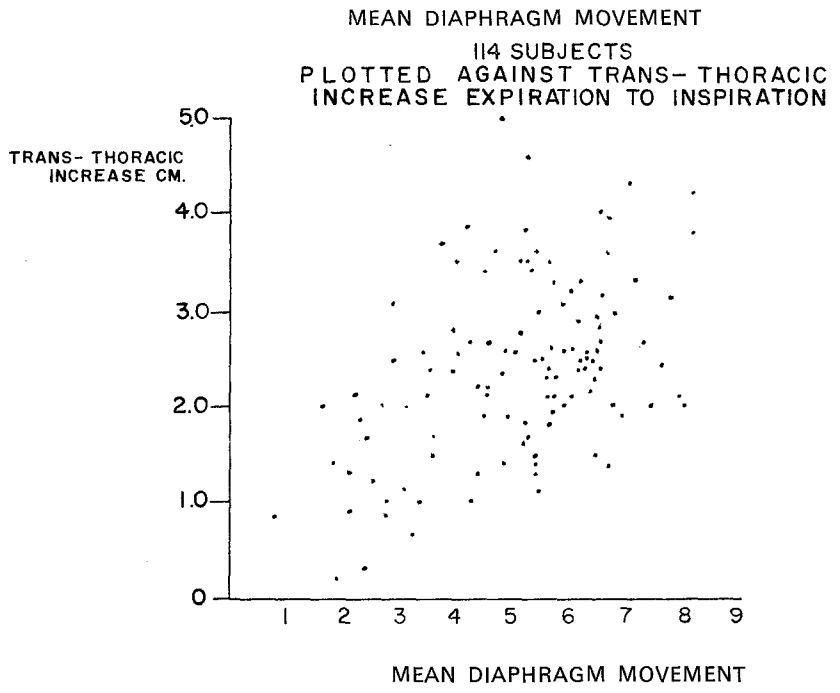

FIG. 7

Relation of diaphragm movement to change in transthoracic diameter.

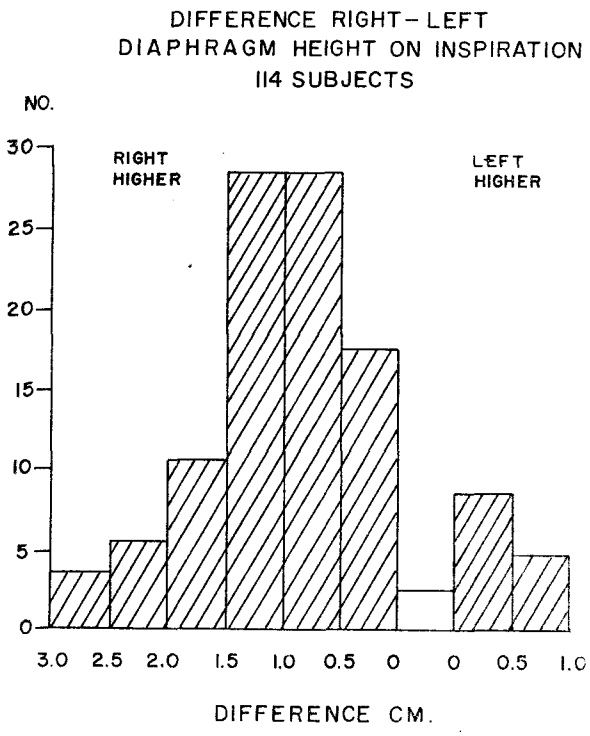

FIG. 8

Difference in height between the right and left domes at full inspiration.

Poor diaphragm movement is, therefore, not evidence of a poor vital capacity. On the other hand, good diaphragm movement is rarely observed in patients with severe emphysema.

The mean diaphragm movements were plotted against the trans-thoracic width increase, expiration to inspiration, and no relationship was demonstrated. (Table 7).

3. Normal height of diaphragm domes.

The right diaphragm is normally higher than the left. (Wynn-Williams, 1954, Freedman, 1950). Difference in the height of the 2 domes on inspiration is expressed in Table 8. The left hemidiaphragm was higher in 14 persons (12 per cent) without an obvious explanation such as a large gastric gas cap or a gas-filled colon. In 5 persons, the left was higher by from 5 to 8 mm. Of those higher on the right, only 10 (9 per cent) were higher by more than 2·0 cm and none were higher than the left by more than 3·0 cm.

4. Trans-thoracic diameter.

The absolute transverse dimension ranged from 25 to 36 cm in the 114 persons. Increase in the transverse thoracic diameter, expiration to inspiration (Table 7) varied from 0·2 to 5·1 cm, with 52 of 114 (46 per cent) increasing by from 2 to 3 cm.

CONCLUSIONS

Inequality in movement of the 2 diaphragmatic domes is common. In the young male population examined in this series, greater right movement is commoner than left. Differences of over 1·5 cm are uncommon.

Healthy subjects frequently move the diaphragms less than 3 cm (mean).

The relationship between mean diaphragm movements and vital capacity is variable. The relationship between mean diaphragm movements and the trans-thoracic diameter increase (expiration to inspiration) is variable.

On inspiration, the left hemidiaphragm may occasionally be level with or higher than the right, but this difference is unlikely to be greater than 1 cm. The right hemidiaphragm may normally be 3·0 cm higher than the left, but usually will be less than 2·0 cm higher.

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