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LUNG FUNCTION IN RELATION TO THORACIC SPINAL MOBILITY AND KYPHOSIS

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ABSTRACT. Mobility and kyphosis of the thoracic spine were correlated with lung function in 185 men and 87 women not suffering from respiratory disease. Curvatures of the spine were measured goniometrically with inclinometers and a compass, and lung function by spirometry. Vital capacity and forced expiratory volume in 1 sec had significant positive correlations only with forward and lateral flexion. The strongest correlations were with forward flexion (r=0.16 to 0.24, p<0.05). The results and possible advantages of mobilizing the thoracic spine in pathological conditions of the lungs and the spine are discussed.

Key words: lung function, thoracic spine, mobility, kyphosis

Pulmonary ventilation involves expansion and contraction of the lungs. Part of the effort exerted by the inspiratory muscles goes into stretching the elastic structures of the lungs and thorax. The elastic properties of the lungs are produced by surface tension in the alveoli and elastic fibres throughout the lung tissue. The elasticity of the thorax is due to the muscles, tendons, connective tissues and joints of the chest (3).

The expansion and contraction of the lungs are caused by anteroposterior movement of the chest cage and movement of the diaphragm (3). The ribs are involved in both movements (7). The head of a rib articulates with two adjacent vertebrae (costovertebral joints) and its tubercle articulates with the transverse process of the lower vertebra (costotransverse joint). For this reason an anatomical relationship between vertebral mobility and lung function seems possible.

To our knowledge no research has been made on the relationship between lung function and thoracic vertebral mobility measured in the three planes. In the present study, spirometry results are compared with measurements of thoracic spinal mobility and kyphosis in subjects of a study on chronic low back pain.

MATERIAL AND METHODS

Subjects

The subjects in this study were originally selected for a research project on chronic low back pain. Men and women with chronic or recurrent low back pain, who were doing at least moderately strainful work, were selected. They were seen by a physician, and patients with a medical history of lung disease (5% of the men, 1% of the women) were eliminated from the study.

The remaining subjects comprised 185 men and 87 women. Table I gives pertinent data on the subjects. Apart from chronic low back pain, their medical histories showed the following chronic or current disorders: neck and shoulder pain 36%, pain in the limbs 29%, gastrointestinal disorders 16%, neurological or psychiatric disorders 11%, hypertension 10%, dermatological disorders 5%, others 13%. The medical histories revealed one woman with Scheuermann's disease, and one man with pain in the thoracic spine. Their spinal mobility and spirometry results did not differ substantially from those of the other subjects, so they were included in the study.

Methods

Measurements of lung function. A Bernstein-type spirometer (Kifa, Sweden) was used to measure vital capacity (VC) and forced expiratory volume during 1 sec (FEV_1). These are given in per cent of their predicted values (VC% and FEV_1%). The reference values were taken from Berglund et al. (1).

Measurements of mobility and kyphosis of the thoracic spine. The methods and their reliability assessments have been described in detail earlier (10, 11). The measurements were conducted by a physiotherapist who had been familiarized with the methods by means of practice runs.

The frontal and sagittal curves were measured by inclinometric methods. The levels of measurement were the upper lumbar and thoracic spine. The difference between the inclines of the two levels in the maximum bending position indicated the mobility and curvature of the thoracic spine.

Forward flexion was measured with the subject sitting on a stool and bending forward maximally.

Extension was measured with the patient depressing his pelvis maximally from a crawling position.

Lateral flexion was measured after the subject had moved his open hand as far as possible down the side of his leg, starting from a neutral standing position. The results for the two sides were added together.

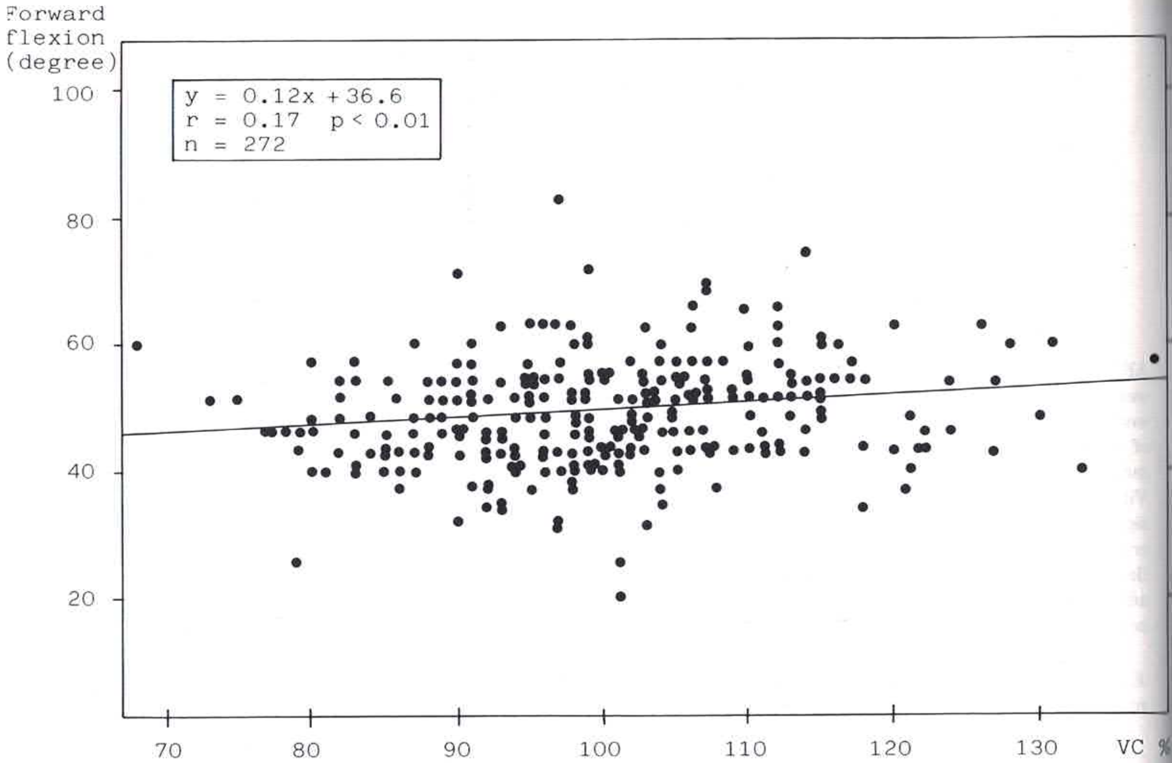

Fig. 1. Relationship between thoracic forward flexion and vital capacity (%) in all the subjects.

Kyphosis was measured with the subject in a neutral standing position.

Rotation was measured with a compass attached to an auxiliary tool: the subject sat on a stool and rotated his trunk as far as possible while looking backwards. The reference points for the thoracic rotation measurements were, cranially, the suprasternal notch and spinous process of Th 1 and, caudally, the xiphoid process and the spinous process of the corresponding horizontal level. The results for the two sides were added together.

Statistical analyses

Age, anthropometric factors and low back pain correlate moderately with spinal mobility (12). The same finding was made for thoracic mobility in the subjects of this study. The effects of age, height, weight and degree of low back pain were therefore eliminated by means of partial correlation analyses (4) in the correlation calculations between thoracic mobility and lung function.

The missing observations evident in Table III were replaced by the mean values, and all the subjects were included in the calculations of significance.

t-Tests for non-matched groups were used to calculate statistical significance between the means.

RESULTS

Table II shows the spirometry results. The means of both FEV_1% and VC% were smaller in the men, but the difference was statistically significant only in VC% ($p<0.001$).

Table I. *Data on the subjects*

	Men, *n*=185		Women, *n*=87	
	Mean	SD	Mean	SD
Age (years)	44.1	5.2	45.6	5.7
Height (cm)	174.6	5.9	161.3	6.0
Weight (kg)	81.7	13.4	70.5	13.7

Table II. *Respiratory function of the subjects*

	Men, *n*=185		Women, *n*=87	
	Mean	SD	Mean	SD
FEV_1 (l)	4.2	0.6	3.1	0.5
FEV_1 %	106.3	13.2	108.7	13.5
VC (l)	5.1	0.7	3.7	0.6
VC %	98.2	11.3	104.4	12.3

Table III. *Mobility and kyphosis of the thoracic spine (degrees)*

	Men			Women		
	n	Mean	SD	*n*	Mean	SD
Forward flexion	185	49.6	8.3	87	46.9	8.7
Extension[a]	182	−21.4	12.7	79	−16.4	12.6
Lateral flexion	185	32.5	10.4	87	32.1	11.0
Rotation	185	30.0	8.8	87	24.4	8.4
Sum of mobilities	182	89.8	23.3	79	88.2	23.2
Kyphosis	185	36.9	8.3	87	29.0	9.2

[a] Negative results mean that ventral concavity of the thoracal spine persisted during extension.

Table III shows the results of the mobility and kyphosis measurements of the thoracic spine. Mobility was greater for men, except in extension. The differences between the sexes were statistically significant for forward flexion ($p<0.05$), extension ($p<0.01$), rotation ($p<0.001$) and kyphosis ($p<0.001$).

According to Table IV, nearly all the mobility measurements except extension correlated positively with FEV_1% and VC%. Significant correlations were found for all the coefficients of forward flexion with lung function. Substantial correlations were also found for lateral flexion. There were no clear differences between the correlations for men and women, though both forward flexion and kyphosis in the women had stronger correlations than in the men.

Fig. 1 shows the relationship between forward flexion and VC% in all the subjects. The correlation coefficient was 0.17 ($p<0.01$).

DISCUSSION

Although the subjects suffered from chronic low back pain, they were currently at work. For most of them the back pain was not acute, and they were able to perform the movements for the measurements of spinal mobility—though the position for the extension measurement caused discomfort for some of them (4.0%) and had to be abandoned. Apart from lateral flexion, the means of the mobility measurements were not lower than those of normal subjects in previous studies (10, 11). VC% was pathological (below 80% of the predicted value) in only a few cases (Fig. 1). So the subjects probably did not differ substantially from the normal in the functioning of the lungs and thoracic spine.

Elevation and depression of the ribs during respiration, like forward flexion of the spine, occur in the sagittal plane, so it is possible that forward flexion gives an indirect measure of mobility in the costovertebral articulations. This may explain the correlations between forward flexion and lung function found in this study.

On the other hand, it should be pointed out that measurement of forward flexion gives the ourvature during maximum bending. This, together with the positive correlations of kyphosis and the low correlations of extension, may indicate that the curvature of forward flexion is favourable for breathing. This explanation agrees with the results of studies on lung function in scoliosis (15) and Scheuermann's disease (6), which showed a positive relation between the degree of kyphosis and lung function.

The correlation coefficients between mobility and lung function were only moderate, indicating a

Table IV. *Correlation coefficients of thoracic mobility and kyphosis with FEV_1% and VC% after the effects of age, height, weight and degree of low back pain have been eliminated by partial correlation analyses*

	Men, n=185		Women, n=87	
	FEV_1 %	VC %	FEV_1 %	VC %
Forward flexion	0.18*	0.16*	0.24*	0.23*
Extension	−0.05	−0.04	−0.05	0.03
Lateral flexion	0.10	0.18*	0.13	0.18
Rotation	0.10	0.07	−0.02	0.03
Sum of mobilities	0.11	0.14	0.10	0.17
Kyphosis	0.11	0.09	0.18	0.16

* $p>0.05$.

marginal significance of thoracic mobility in the lung function of healthy persons. Strong correlations were unlikely owing to the indirectness of the connection between lung function and spinal mobiltiy, and the divergence of other more relevant factors.

In pathological conditions of the spine involving marked stiffness, like scoliosis and ankylosing spondylitis, thoracic mobility is probably of greater importance for pulmonary function, and mobilizing exercises are recommended in such cases (2, 14). In respiratory diseases with impaired lung function, even a slight decrease of breathing work could be therapeutically advantageous.

For ordinary chest physiotherapy, the principal methods are breathing exercises and muscle training (5, 13). On the other hand, Helmholz et al. (5) point out that a loosening of contractures and stiffened joints decreases the work of breathing to a remarkable extent. But mobilizing the thoracic spine has not been explicitly proposed as a method of chest physiotherapy (5, 13).

Active or passive mobilization of the thoracic spine is a treatment mainly for primary musculoskeletal disorders (8, 9). Passive methods of mobilizing the ribs are also used (8, 9), but we do not know to what extent these methods increase mobility, or whether they are sufficient to improve the respiratory function.

The result of this study give some indications that increased mobility of the thoracic spine, which probably improves rib mobility indirectly, may be of advantage to lung function. To confirm this, studies on patients with respiratory diseases and/or stiffness of the thoracic spine are desirable.

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