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RESEARCH ARTICLE

Correlation of Cobb's angle with pulmonary function in idiopathic scoliosis

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ABSTRACT

Background: Idiopathic scoliosis, which accounts for the 80-85% of all lateral spine curvatures, distorts the chest wall anatomy and results in functional pulmonary disability. **Aims and Objectives:** The aim of this study is to evaluate the pulmonary function in patients with asymptomatic idiopathic scoliosis and matched controls and to study the correlation between the degree of spinal deformity (Cobb's angle) and pulmonary function test (PFT) parameters. **Materials and Methods:** This study included 35 (27 males and 8 females) patients with idiopathic scoliosis in the age group of 15-30 years, with mean Cobb's angle 62°. Standing anteroposterior X-rays of the spine were taken. The radiographs were assessed and angle of curvature was measured by the Cobb's method. PFT parameters were recorded and compared with matched controls, and their correlation with Cobb's angle was studied. The data were analyzed with the Student's unpaired *t*-test and Pearson's correlation coefficient. **Results:** Pulmonary parameters such as tidal volume, vital capacity (VC), forced VC (FVC), forced expiratory volume in first second (FEV_1), maximum mid-expiratory flow rate, peak expiratory flow rate, and maximum voluntary ventilation were significantly reduced in scoliosis patients than controls, and they were inversely correlated with Cobb's angle. However, the mean FEV_1/FVC ratio at rest in scoliosis patients was within normal limits and the ratio was not correlated with Cobb's angle. **Conclusion:** Thus, it can be concluded that patients with idiopathic scoliosis show reduced lung volumes and capacity on PFT and the pulmonary parameters show strong inverse correlation with the severity of the spinal deformity (Cobb's angle).

KEY WORDS: Maximum Voluntary Ventilation; Peak Expiratory Flow Rate; Cobb's Angle; Scoliosis; Pulmonary Functions

INTRODUCTION

The principal effect of scoliosis on pulmonary functions believed to be mechanical. The anatomic changes in the chest wall causing impaired movement and reduced compliance that is demonstrable on pulmonary function testing (PFT).[1] The current definition of scoliosis as an abnormal lateral curvature of the spine, Cobb's angle,[2] at least 10°, with concordant vertebral rotation.[3] Scoliosis classification is based on the quantification of the severity of scoliosis by the use of radiographic measurements of the angle of curvature in the spine (Cobb's angle), as well as the level of the apex of the spinal curvature and the number of curves.[2] Many studies have shown that PFTs of patients with idiopathic scoliosis reveal a restrictive defect.[4-8] Defective mechanical coupling of inspiratory muscles to the chest wall leading to a decrease in respiratory muscle mechanics has been shown to contribute to the restrictive properties.[9]

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Many studies have demonstrated a strong correlation between abnormal pulmonary function and the severity of the spinal deformity. However, other factors, such as the distortion of the rib cage associated with the vertebral deformity, may also contribute to the altered ventilation mechanics.[4,6,8,10,11]

Some previous studies have shown an obstructive defect in idiopathic scoliosis.[12-15] Airway obstruction may occur though uncommon. Rotation of the chest can cause displacement/rotation of the intrathoracic and main stem bronchi, or compression of a main stem bronchus against vertebra and mediastinal structures, causing mechanical airway obstruction, reduce expiratory flow rates and increase airway resistance.[13,14] Respiratory abnormalities have been more frequently reported in adolescents with spine curvature >45°. Fatal cardiopulmonary abnormalities are known to develop in these patients.[16-19]

The present study was designed to study the effect of the severity of Cobb's angle (spine curvature) in idiopathic scoliosis patients in the absence of other respiratory diseases on pulmonary function.

MATERIALS AND METHODS

This study was conducted in the Department of Physiology, Karnataka Institute of Medical Sciences, Hubballi, after obtaining the Institutional Ethical Clearance. The cases for this study with clinically recognizable scoliosis were taken from Orthopedic Department, KIMS, Hubballi, and those patients who were visiting the Medical superintendents office to obtain their "Physical Handicap" certificate. They were asymptomatic and had no medical or orthopedic problems other than chest deformity.

This study group comprised 35 patients with idiopathic scoliosis in the age group of 15-30 years, with mean Cobb's angle 62° and ranged from 48° to 110°. There were 27 males and 8 females. All of them gave a history of early onset scoliosis, i.e., scoliotic curves were noticed at 2-4 years of age, and in only one patient, the curve was noticed at the age of 8 years. 30 patients had their curves to the right, and in five, the curves were to the left. All of them had single major curve. In 30 patients, the curves were located in the thoracic region, and in five patients, the curves were in thoracolumbar region. 35 matched controls were selected from the general population. Both groups were of similar age, sex, height, and weight.

Those with a history of chronic respiratory disorders, cardiac disease, systemic disorders affecting respiratory system, mentally handicapped, and smokers were excluded from the study. A thorough history taking and clinical examination were carried out to rule out the exclusion criteria, and the vital data were recorded. Standing height (deformed in scoliotics) was measured without footwear with patients back in contact with the wall and with both heels together and touching the base of the wall. As the spine is distorted in scoliotic patients, their deformed (actual) heights cannot be used for predicting lung volumes or selecting controls. Hence, the corrected height was calculated from arm span, with the method described by Hepper et al.[19] Measurement of arm span was obtained by having the patient stand against a wall and stretching his/her arms to attain the maximal distance between the tips of the middle fingers. Weight was recorded with light clothing using a digital weighing machine. Both the height and weight were measured to the nearest 0.1 cm and 0.5 kg, respectively. None of these patients had received any surgical therapy and was asymptomatic.

Standing anteroposterior (AP) radiographs (X-rays) of the spine were taken from all cases in Radiology Department of KIMS, Hubballi. The same techniques were used throughout the study. The radiographs were assessed for the position and type of curve. The angle of curvature was measured by the Cobb's method. Patients were divided into three groups based on the degree of Cobb's angle (mild 20-50, moderate 51-70, and severe >71).

Various spirometric measurements were taken on both control and study groups with a portable, computerized spiralizer - SPL 95 (France International Medical, Lyon).The recordings were carried out between 10 am and 12 noon. All the maneuvers were performed in sitting position. Thorough instructions were given to each patient regarding the test and sufficient time was provided to practice the maneuvers. A soft nose clip was put over the nose to occlude the nostrils, and disposable mouthpieces were used to minimize cross infection.

Statistical Analysis

The data were analyzed with the Student's unpaired *t*-test and Pearson's correlation coefficient. The statistical analysis was carried out with SPSS 13.

RESULTS

This study group comprised 35 patients with idiopathic scoliosis in the age group of 15-30 years, with mean Cobb's angle 62° and ranged from 48° to 110°. The recorded anthropometric data in controls and study group did not show any statistical significance as shown in Table 1. The recorded vital data show a significant difference in respiratory rate of cases than controls as shown in Table 2.

Pulmonary parameters such as tidal volume (TV), vital capacity (VC), forced VC (FVC), forced expiratory volume in first second (FEV_1), maximum mid-expiratory flow rate (MMEF), peak expiratory flow rate (PEFR), and maximum voluntary ventilation (MVV) were significantly reduced in cases than controls as shown in Table 3, and they were inversely correlated with Cobb's angle as shown in Table 4. However, the mean FEV_1/FVC ratio at rest in cases was comparable to controls and is within normal limits, and the ratio was not correlated with Cobb's angle.

DISCUSSION

Although scoliosis has generally been associated with the development of restrictive pulmonary disorder resulting in decreased lung volume as manifested on PFT. The decrease in lung volume is multifactorial and may reflect different pathophysiologies depending on the age of the patient at the onset of scoliosis and the chronicity of the problem. It is mainly due to restriction which is related to the severity of scoliosis (Cobb's angle), the location of the curve, and the loss of normal thoracic kyphosis.[20] Severe degree of scoliosis affects the size and dimension of thoracic cage, and hence the pulmonary function.[21-23] There is severe reduction of the lung volume of patients with Cobb's angle more than 90°, and it is of restrictive type.[24]

Differences of opinion exist about relationship of the severity of scoliosis and degree of reduction in pulmonary parameters. Some studies suggest a direct correlation,[23,25] and some studies have shown no correlation.[4,6,8]

Observations in this study showed that idiopathic scoliosis produces restrictive type of pulmonary defect. Pulmonary parameters such as TV, VC, FVC, FEV_1, MMEF, PEFR, and MVV were significantly reduced in cases than controls and inversely correlated with the Cobb's angle. However, the mean FEV_1/FVC ratio at rest in cases was comparable to controls and is within normal limits, and the ratio was not correlated with Cobb's angle.

Table 1: Anthropometric data of scoliosis cases and controls

Parameters	Mean±SD		*t* value	*P* value
	Cases	Controls		
Age (years)	22.30±4.62	23.30±2.31	0.52	>0.05
Height (cm)	160.3±4.36	161.41±5.42	0.62	>0.05
Weight (kg)	49.6±5.33	50.58±6.18	0.12	>0.05
BMI (kg/m^2)	18.51±2.01	18.28±1.39	0.52	>0.05

SD: Standard deviation, BMI: Body mass index

Breathing pattern is significantly altered in severe scoliosis at rest, on exertion, and during sleep. The respiratory rate tends to be higher and the TV lowers than normal. Despite its absolute value, TV is actually increased relative to the VC. To accomplish this, patients need an inspiratory effort that is often more than twice normal, and this is achieved with a much higher than normal transdiaphragmatic pressure, requiring increased contribution from the abdominal expiratory muscles.[26]

The compliance of the respiratory system is reduced. In particular, the reduced chest wall compliance plays an important role in reducing lung volumes and correlates closely with the Cobb's angle and with the decrease in FVC.[27]

The mean FVC and FEV_1 in idiopathic scoliosis patients were reduced and inversely correlated with the Cobb's angle. This may be due to abnormality of ventilatory mechanics.[9] However, the mean FEV_1/FVC ratio was within normal limits. There was no statistically significant difference between two groups. Many observers have got similar results.[4-6,8,28] Hence, the observations of the current study are suggestive of a restrictive defect in scoliosis, which is mainly due to alteration in respiratory mechanics due to the scoliosis.

The mean flow rates MMEF was significantly low in cases than controls. The initial portion of the FEV is effort dependent. PEFR and MMEF fall in this portion.[4]

MVV and PEFR were significantly low in cases than controls. Ting and Lyons[29] got similar result. They showed 50% reduction in MVV and attributed this to decreased lung volumes, fixed thoracic cage, and loss of musculoskeletal power which are characteristics of scoliosis. Decreased values of PEFR in the absence of other indications of airway obstruction were probably evidence of a reduction in ventilatory power intrinsic in the musculoskeletal thoracic deformity of scoliosis or an increase in the work of breathing or both.[30]

In the present study, there was no difference observed between scoliosis patients and controls with respect to body size variables. Hence, the changes observed can be attributed to the chest deformity in scoliosis patients. It is apparent from this study that appreciable pulmonary deficits do occur and deficits may not cause symptoms but are easily detected by simple spirometry, a technique easily performed in hospitals.

Table 2: Vital data of scoliosis cases and controls

Parameters	Mean±SD		*t* value	*P* value
	Cases	Controls		
Pulse rate (beats per min)	76.80±5.32	76.60±5.74	0.14	>0.05
Blood pressure Systolic/diastolic (mmHg)	116.47±10.53	116.27±9.98	0.07	>0.05
	75.07±6.16	77.93±5.64	1.87	>0.05
Respiratory rate (per min)	26.00±2.32	16.43±2.18	7	<0.001

Table 3: Pulmonary function parameters of scoliosis cases and controls

Parameters	Mean±SD		*t* value	*P* value
	Cases	Controls		
Tidal volume (L)	0.27±0.06	0.41±0.08	7.6	<0.001
Vital capacity (L)	1.45±0.46	2.48±0.36	9.7	<0.001
FVC (L)	1.32±0.44	2.23±0.36	8.7	<0.001
FEV_1 (L)	1.16±0.40	1.95±0.35	8	<0.001
FEV_1/FVC	0.88±0.07	0.87±0.06	0.6	<0.05
MMEF (L/s)	1.54±0.63	2.37±0.79	4.4	<0.001
PEFR (L/s)	2.92±0.99	4.72±1.42	5.6	<0.001
MVV (L/min)	54.31±13.62	85.71±16.42	8	<0.001

SD: Standard deviation, TV: Tidal volume, VC: Vital capacity, FEV_1: Forced expiratory volume in first second, FVC: Forced vital capacity, MMEF: Maximum mid-expiratory flow rate, PEFR: Peak expiratory flow rate, MVV: Maximum voluntary ventilation

Table 4: Correlation of pulmonary function parameters with Cobb's angle

Parameters	Correlation coefficient	*P* value
TV (L)	−0.42	<0.05
VC (L)	−0.72	<0.001
FVC (L)	−0.75	<0.001
FEV_1 (L)	−0.74	<0.001
FEV_1/FVC	0.03	>0.05
MMEF (L/sec)	−0.60	<0.001
PEFR (L/sec)	−0.37	<0.05
MVV (L/min)	−0.80	<0.001

TV: Tidal volume, VC: Vital capacity, FEV_1: Forced expiratory volume in first second, FVC: Forced vital capacity, MMEF: Maximum mid-expiratory flow rate, PEFR: Peak expiratory flow rate, MVV: Maximum voluntary ventilation

The important point brought out is the apparent dissociation between subjective symptom and objective evidence of pulmonary deficits in patients of this age with scoliosis. One limitation of this study is small sample size, a similar study involving larger sample would yield more accurate results. There is no conflict of interest to declare in this study.

CONCLUSION

Thus, it can be concluded that patients with idiopathic scoliosis show reduced lung volumes and capacity on PFT and the pulmonary parameters show a strong inverse correlation with the severity of the spinal deformity (Cobb's angle).

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