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Relationship between pulmonary function and exercise tolerance in patients with ankylosing spondylitis

Ü. Seçkin[1], N. Bölükbasi[2], G. Gürsel[3], S. Eröz[2], V. Sepici[2], N. Ekim[3]

[1]Ankara Numune Education and Research Hospital, Department of Physical Medicine and Rehabilitation; [2]Department of Physical Medicine and Rehabilitation and [3]Department of Respiratory Disease, Gazi University Faculty of Medicine, Ankara, Turkey.

Ümit Seçkin, MD, Specialist; Nesrin Bölükbasi, MD, Associate Professor; Gül Gürsel, MD, Associate Professor; Serpil Eröz, PhD, Physiotherapist; Vesile Sepici, MD, Professor; Numan Ekim, MD, Professor.

Please address correspondence and reprint requests to: Ümit Seçkin, MD, Güvenlik Cad. No:113/5 Asagi-Ayranci, Ankara, Turkey. E-mail: pinarb@ato.org.tr

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ABSTRACT

Objective

It is a well-known fact that pulmonary function is altered in ankylosing spondylitis (AS) mainly due to the restriction of chest wall movements. The objective of this study was to investigate whether alterations in pulmonary function affected exercise capacity.

Methods

Twenty male patients with definite AS and 20 age-matched healthy male controls were recruited for the study. All subjects were assessed for functional status by BASFI and physical activity level. Measurement of chest expansion and lumbar spinal flexion by the modified Schober method were performed. Pulmonary function tests and exercise testing on a treadmill using the Bruce protocol were performed.

Results

The physical activity level was similar in both groups. In the AS group the mean BASFI score suggested good functional capacity, while chest expansion and modified Schober measurements were significantly lower and pulmonary function tests revealed restrictive lung disease. The results of the exercise tolerance test were similar in both groups except for the rate of perceived exertion.

Conclusion

This study demonstrated that exercise capacity in AS patients is not influenced by the limitation of chest wall movements, probably due to the maintenance of moderate physical activity along with an active life style.

Introduction

Ankylosing spondylitis (AS) is a chronic, systemic, inflammatory disease that affects mainly the axial skeleton (1). Involvement of the lungs measured as reduced lung volumes is a known manifestation of the disease. This has been suggested to be a consequence of reduced mobility of the thoracic cage (2). This study aimed to assess the pulmonary function and exercise tolerance in AS and to investigate whether exercise tolerance is altered in correspondence to the decline in pulmonary function.

Materials and methods

Twenty male patients with definite AS according to the modified New York criteria (3) and 20 age-matched healthy male volunteers with a similar physical activity level were recruited for the study. Exclusion criteria included coexisting cardiac and respiratory disease or the presence of severe arthritis in the legs which interfered with exercising on the treadmill.

Age, disease duration (based on the onset of low back pain), smoking history, and physical activity level (sedentary, or regular recreational sport activity) were recorded. Regular recreational sport activity was defined as a modest amount of exercise such as walking, cycling over 2 miles each day, or swimming twice a week. The Bath Ankylosing Spondylitis Functional Index (BASFI) was used for the assessment of functional ability in patients with AS. This instrument consists of 8 specific question regarding function and 2 questions reflecting the patient's ability to cope with everyday life. Each question is answered on a 10 cm horizontal visual analog scale, the mean of the scores giving the BASFI score (0-10) (4).

Physical examination was performed by the same physician between 9 and 11 am. Measurements of the weight and height were recorded and the body mass index was estimated by the following formula: weight (kg)/height^2 (cm) (5). Chest expansion was measured with a tape measure placed circumferentially around the chest wall at the fourth intercostal space (6). Flexion of the lumbar spine was assessed by the modified Schober test (7). All subjects underwent radiography of the chest. Pulmonary function tests included measurement of the forced vital capacity (FVC), forced expiratory volume in one second (FEV1), FEV1/FVC, peak expiratory flow (PEF), and maximum mid-expiratory flow rate (MMFR).

Exercise testing was performed on a treadmill using the Bruce protocol. The following parameters of the exercise tolerance tests were evaluated: rating of perceived exertion (RPE); double product (DP = heart rate x systolic blood pressure at a given workload during the last minute of the second stage of the Bruce protocol); metabolic equivalent (MET) level achieved; duration of exercise (in minutes); maximum heart rate achieved/

predicted maximum heart rate (% max.) and functional aerobic impairment (FAI) (8-10). The RPE scale represents the subjective expression of exercise stress felt by the patient, which can range from "no noticeable feeling" to "maximum effort" (6 and 20 respectively). It measures the patient's overall evaluation of fatigue, chest pain, and leg pain (Fig. 1). A perceived exertion of 12-16 corresponds to a heart rate response of between 60% - 85%. A 12-lead ECG was performed at rest and the ECG was monitored throughout the exercise period. The test was stopped when the patient could no longer continue exercising.

In the statistical analysis the χ^2 test was used to compare the physical activity level in both groups, and the Independent-t test was used to determine the significance level between the AS and the control group. The Pearson correlation coefficient was used to measure the correlation between variables (pulmonary function, exercise tolerance and clinical variables). The Mann-Whitney-U test was used for the comparison of the RPE between the two groups.

6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
20	

Fig. 1. Categories of the RPE scale.

Results

Twenty male patients with definite AS (mean age 37.4 ± 8.7, mean disease duration 12 ± 6.7 years) and 20 healthy male controls (mean age 36.2 ± 7.6) participated in the study. The BASFI score of the patients ranged from 2.07 to 5.04 (mean: 3.04 ± 1.02). The two groups were similar in terms of age, height, weight and physical activity level ($p > 0.05$). BMI, chest expansion and modified Schober measurements were significantly lower in the AS group. Table I shows the characteristics of the subjects. There were no specific findings of primary lung disease in the postero-anterior chest radiographs in any subject. Fifteen of the subjects in each group were smokers. There was no significant difference in smoking status between the two groups.

Pulmonary function tests revealed that FVC and FEV1 were significantly lower in the AS group; however, FEV1/ FVC and MMFR values were similar. These results confirmed the presence of restrictive lung disease in the AS group. Mean values of the pulmonary function tests are presented in Table II.

Among the variables of exercise tolerance, only the RPE was significantly higher in the AS group ($p < 0.05$), while DP, exercise time, MET and FAI levels were similar in both groups. Mean val-

Table I. Characteristics of the subjects.

	AS	Control	P
Age (years)	37.4 ± 8.7	36.2 ± 7.6	> 0.05
Height (cm)	174.8 ± 5.3	172.8 ± 5.6	> .05
Weight (kg)	70.1 ± 9.1	73.3 ± 7.9	> .05
BMI	22.9 ± 2.5	24.5 ± 2.4	< .05
Physical activity level (n):			
Sedentary	18	17	< 0.05
Regular recreational sports activity	2	3	
Modified Schober method (cm)	2.5 ± 1.1	5.3 ± 0.7	< 0.0001
Chest expansion (cm)	2.9 ± 1.7	5 ± 0.9	< 0.0001
Disease duration (year)	12 ± 6.7	-	
BASFI Score	3.04 ± 1.02	-	

Table II. Results of pulmonary function tests.

	AS	Control	P
FVC (L)	4 ± 0.7	4.9 ± 0.7	< 0.0001
% FVC	85.3 ± 14.7	105.2 ± 11	< 0.0001
FEV 1 (L)	3.4 ± 0.7	4.1 ± 0.6	< 0.05
% FEV 1	86 ± 17	104.4 ± 10.5	< 0.05
FEV 1/ FVC	84.7 ± 9.8	83.1 ± 5.3	> 0.05
PEF (L/sec)	8.2 ± 2	9.2 ± 1.5	> 0.05
% PEF	89.5 ± 21.4	100.1 ± 14.4	< 0.05
MMFR (L/sec)	3.5 ± 1.1	4 ± 1	> 0.05
% MMFR	79 ± 26	87.6 ± 19.2	> 0.05

FVC: forced vital capacity; FEV 1: forced expiratory volume in 1 second; PEF: peak expiratory flow; MMFR: maximum mid-expiratory flow rate.

Table III. Statistical assessment of the results of the testing.

	AS	Control	P
% max.	96.4 ± 6.6	97.5 ± 7.1	> 0.05
Double product	27.1 ± 3.8	26.9 ± 4	> 0.05
Exercise duration (min.)	10.9 ± 2	11.9 ± 2.4	> 0.05
Metabolic equivalent level	12.4 ± 2.2	13.3 ± 2.6	> 0.05
Functional aerobic impairment	9.6 ± 14.8	5.3 ± 18.4	> 0.05
Rating of perceived exertion *	**16 (14-17)****	**14 (14-15)****	**< 0.05**

* Mann Whitney-U test; ** **Median (inter-quartile range)**

ues for the exercise tolerance tests are presented in Table III. Pearson correlation analysis results revealed that RPE was correlated with %FVC (r = -0.49), %FEV1 (r = -0.49), % PEF (r = -0.53) and chest expansion (r = -0.52). There was no correlation between disease duration versus pulmonary function and exercise tolerance. Reduction in chest expansion showed a correlation with pulmonary function tests (r = 0.4) but not with exercise tolerance.

Discussion

Rigidity of the thorax occurs in AS with bony ankylosis among thoracic vertebrae, and the costovertebral, costotransverse, sternoclavicular and sternomanubrial joints. Progressive kyphosis adds deformity to the rigidity of the thorax (11). Involvement of the lung is a rare and late manifestation of AS. It is characterized by apical fibrosis. Pulmonary ventilation is usually well maintained and increased diaphragmatic contribution helps to compensate for chest wall rigidity (1, 12). The typical respiratory function abnormalities in AS are those of a restrictive defect and pulmonary function tests showed restrictive changes, with decreased FVC, FEV1 but normal FEV1/FVC (13).

Studies by Feltelius have shown an association between the limitation of chest expansion and restriction of vital capacity (14). In our study, chest expansion and modified Schober measurements were found to be lower in the AS group, as expected, and pulmonary function tests confirmed a restrictive type of impairment in pulmonary function.

Studies on patients with rheumatoid arthritis (RA) and osteoarthritis reveal a reduced exercise tolerance, especially in the group with RA compared with controls (15). In our study however, both the disease and control groups achieved similar performances in exercise testing, while the AS group seemed to be more affected on exertion and patients complained of respiratory symptoms such as dyspnoea to a higher extent. The higher RPE values noted in the patient group arose from the higher exertion on respiratory functions. However, a study by Carter *et al.* (16) revealed a greater degree of leg fatigue and a similar rate of breathlessness in patients with AS compared to controls. They attributed the exercise intolerance to peripheral muscle function impairment due to deconditioning . The reason for the difference in RPE can be attributed to the limitation of chest wall movements in the AS group during exercise. A previous study pointed out that maximum aerobic capacity is not correlated with chest expansion, but showed a correlation with vital capacity (11). Elliott *et al.* concluded that maximum ramp exercise performance in AS subjects with chest wall restriction is decreased. Deconditioning or cardiovascular impairment rather than ventilatory impairment appears responsible for the observed reduction of VO_2 max. (17). Similar to earlier surveys, our results suggest that, although a restriction of chest expansion may result in the reduction of vital capacity, it is not a major factor determining exercise tolerance.

Mau *et al.* studied 32 AS patients and concluded that 78% of their patients with a mean disease duration of 18 years had good or sufficient functional capacity, indicating an overall good functional prognosis (18). Another study by Ringsdal and Helin also concluded that, despite long-term morbidity with a gradual loss of functional capacity, 85% of patients were still able to work after more than 20 years of illness (19). In our study no correlation was found between disease duration and either pulmonary function or exercise tolerance. As lower BASFI scores show better functional ability, these results can be explained by the adequate physical activity level versus long disease duration in the AS group in our study.

In recent years exercise has increasingly been advocated as a means of preserving upright posture, improving spinal flexibility and reducing back pain (15, 20). In our study there were examples of subjects taking a moderate amount of daily exercise who were able to achieve a maximal aerobic capacity close to their predicted values, despite having restricted chest expansion. Counseling and encouragement for patients with AS to take more regular exercise and to participate in sports activities should be given greater emphasis.

Although our study failed to show any significant difference in pulmonary function tests between smokers and nonsmokers, it would be prudent to encourage patients with AS to stop smoking in view of the theoretical risk of compounding a restrictive lung disorder with an obstructive component.

We conclude that exercise capacity in AS patients who functionally lead an independent life is not influenced by the limitation of chest wall movements. An active life style with maintenance of moderate physical activity probably is adequate for the preservation of exercise capacity in patients with AS.

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