The Effects of Respiratory Functions and Respiratory Muscle Strength on Exercise Capacity and Quality of Life in Patients with Ankylosing Spondylitis

Şule Özbay KAYA[1], Özgür BOSTANCI[2], Muhammet Hakan MAYDA[3]

Ankilozan Spondilitli Hastaların Solunum Fonksiyonları ve Solunum Kas Kuvvetlerinin Egzersiz Kapasitesi ile Yaşam Kalitesi Üzerine Etkisi

ABSTRACT

This study aims to examine the effects of impaired respiratory functions and respiratory muscle strength (RMS) on exercise capacity and quality of life in patients with ankylosing spondylitis (AS). In the study, 28 AS patients (female: 20, male: 8; age: 41.93±9.49) and 28 healthy individuals (female: 20, male: 8; age: 39.61±10.78) were evaluated. Descriptive information, clinical histories and chest expansion measurements of the patients were obtained. Respiratory function tests (RFT) were measured with a spirometer and RMS was measured with a respiratory pressure meter. Disease activity was assessed with the Bath Ankylosing Spondylitis Functional Index (BASFI). Functional exercise capacity was measured using the 6-min walk test (6MWT) and vital signs. SF-36 quality of life scale was used to evaluate the quality of life of the patient group. The average values of RFT, RMS, 6MWT and vital signs of patients with AS were found to be lower than the control group. FEV1, 6MWT, leg fatigue before and after 6MWT and heart rate after 6MWT parameters were significantly lower in AS patients than in control group ($p<0.05$). In addition, a negative correlation was found between RFT, RMS and BASFI score of the patient group and a positive correlation was found between 6MWT, chest expansion and quality of life parameters. In conclusion, this study showed that the impairments in the musculoskeletal system and respiratory functions in AS patients decrease their respiratory parameters, exercise capacity and quality of life. Exercises that increase RMS should be included in the exercise programs for AS.

Keywords: Ankylosing spondilitis, Respiratory functions, Respiratory muscle strength

ÖZ

Bu çalışmanın amacı Ankilozan Spondilitli hastaların (AS) bozulan solunum fonksiyonları ile solunum kas kuvvetlerinin (SKK) egzersiz kapasitesi ve yaşam kalitesi üzerine etkisini incelemektir. Araştırmada AS tanısı almış olan 28 hasta (kadın: 20, erkek: 8; yaş: 41.93±9.49) ve 28 sağlıklı birey (kadın: 20, erkek: 8; yaş: 39.61±10.78) değerlendirildi. Hastaların tanımlayıcı bilgileri, klinik öyküleri ve göğüs ekspansiyon ölçümleri alındı. Solunum fonksiyon testleri (SFT) spirometre ile SKK ağız içi basınç ölçer ile ölçüldü. Hastalık aktivitesi, Bath Ankilozan Spondilit Fonksiyonel İndeksi (BASFI) ile değerlendirildi. Fonksiyonel egzersiz kapasitesi 6 dakikalık yürüme testi (6DYT) ve vital bulguları kullanılarak ölçüldü. Hasta grubunun yaşam kalitesini değerlendirmek için ise SF-36 yaşam kalitesi ölçeğinden yararlanıldı. AS'li hastaların SFT, SKK, 6DYT ve vital bulguları ortalama değerleri kontrol grubuna göre daha düşük olduğu bulunmuştur. FEV1, 6DYT, 6DYT öncesi ve sonrası bacak yorgunluğu ile 6DYT sonrası nabız parametreleri AS'li hastalarda kontrol grubuna göre istatiksel olarak daha düşüktür ($p<0,05$). Ayrıca hasta grubunun BASFI skoru ile SFT ve SKK arasında negatif; 6DYT, göğüs ekspansiyonu ve yaşam kalitesi parametreleri arasında pozitif ilişki olduğu tespit edildi. Bu çalışma AS'lilerde kas iskelet sisteminde ve solunum fonksiyonlarında meydana gelen bozulmaların hastaların solunum değerlerini, egzersiz kapasitelerini ve yaşam kalitelerini azalttığını göstermiştir. AS'liler için egzersiz programlarında SKK'yi artıran egzersizlere yer verilmelidir.

Anahtar Kelimeler: Ankilozan spondilit, Solunum fonksiyonları, Solunum kas kuvveti

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[1] PT, Şule Özbay KAYA, Physiotherapy, Department of Physical Therapy and Rehabilitation Clinic, Samsun Medicalpark Hospital, fzt.shule@gmail.com, ORCID: 0000-0001-5399-2101
[2] Ass. Prof., Özgür BOSTANCI, Sport Science, Yaşar Doğu Faculty of Sports Sciences Ondokuz Mayıs University, bostanci@omu.edu.tr, ORCID: 0000-0002-7952-1014
[3] Research Assistant, Muhammet Hakan MAYDA, Sport Science, Yaşar Doğu Faculty of Sports Sciences Ondokuz Mayıs University, hakan.mayda@omu.edu.tr, ORCID: 0000-0002-7062-3284

İletişim / Corresponding Author: Muhammet Hakan MAYDA
e-posta/e-mail: hakan.mayda@omu.edu.tr

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INTRODUCTION

Ankylosing spondylitis (AS), which is the main subtype of spondyloarthritis group diseases, is a chronic, systemic, inflammatory and rheumatic disease that causes structural and functional disorders and affecting the musculoskeletal system and extra-articular organs.[1] The most common initial symptoms are chronic low back pain, hardness and stiffness.[2] The progression of the stiffness from the sacroiliac joint to the cervical region causes functional loss in spinal mobility.[3] Extra-systemic symptoms such as peripheral joints, eye, heart, skin, intestine and kidney morbidity risk may accompany with time.[4] In addition, it is reported that respiratory risk factors are high in this patient group.[5] Respiratory involvement as a result of interstitial lung disease or changes in the thorax is well known.[6] In patients with AS, dorsal kyphosis, thoracic stiffness and persistent chest wall immobility are observed due to inflammation in the thoracic vertebrae and costovertebral joints.[7] This situation disrupts the normal movement of the ribs and creates a high rate of restriction on chest wall expansion while respiratory ventilation can be provided through the diaphragm.[6,8] Restrictive respiratory disorders are generally encountered in patients with AS and the reason for this is the decrease in chest mobility and respiratory functions as a result of ankylosis of the thoracic joints.[5,9] Another problem caused by decreased chest mobility is the weakening of the respiratory muscles.[8] Decreased chest expansion causes weakening of intercostal muscles and leads to weakness especially in inspiratory muscles in the future.[8,10] In addition, it has been stated that the weakening of respiratory functions and respiratory muscle strength in patients with AS may be caused not only by the decrease in chest mobility but also by the tendency to fibrosis that occurs as a result of inflammatory processes in the lungs.[5] The quality of life of patients decreases due to stiffness, pain, decrease in exercise capacity, chronic fatigue and dyspnea caused by the respiratory dysfunction.[1,11]

In this regard, physiotherapy applications including exercise programs in addition to medical treatment in patients with AS are of great importance to prevent possible deformities, eliminate the pain and stiffness, maintain exercise capacity, preserve and develop increase muscle strength.[8,12] In this study, it was aimed to compare the respiratory function tests, respiratory muscle strength and exercise capacities of patients with AS to healthy individuals and to analyze the correlation between respiratory muscle strength and quality of life.

MATERIAL AND METHODS

Patients and Study Design

In the study, 28 patients (female: 20, male: 8) who were diagnosed with Ankylosing Spondylitis by a specialist physician according to Modified New York Criteria, who applied to the Department of Physical Therapy and Rehabilitation of Medical Park Samsun Hospital for treatment and 28 healthy individuals (female: 20, male: 8) that matched in terms of descriptive characteristics were included (Table 1). The groups were homogeneous in terms of demographic and clinical characteristics except for the parameters of height and exercise frequency ($p>0.05$). Patients with primary cardiovascular and/or respiratory disease, neurological effects, those using any assistive device for respiration, and patients with active lower extremity arthritis that would interfere with exercise testing were excluded. The study was carried out at Medical Park Samsun Hospital.

Ethical Dimension of Research

The research was designed according to the Helsinki Declaration rules.[13] Approval was obtained from a local clinical research ethics committee (OMU KAEK 2013/491).

Demographic and Clinical Data

Age, gender, disease duration, smoking and exercise history of the patient and control groups were obtained through face-to-face interviews. Heights and weights were measured (SECA, Germany).

Chest Expansion

In order to evaluate the costovertebral joint movements of the patients, chest expansion values were obtained by measurements from axillary, epigastric and subcostal regions. For the measurement of chest expansion, the differences between the patient's chest circumference measurements at the time of deep inspiration and forced expiration were taken with the help of a tape measure and recorded.[14]

Pulmonary Functions and Respiratory Muscle Strength

Forced vital capacity (FVC), forced expiratory volume in one second (FEV1) capacities and FEV1/FVC ratio were measured with spirometer (Saint Paul, MN, USA).[15]

Maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) parameters were measured using MicroRPM device (CareFusion Micro Medical, Kent, UK).[15] After fitting the appropriate filter and mouthpiece, the nasal airway was closed with a clip. The subject completed the MIP test in sitting position by inspiration at the residual volume at a maximal rate for 1-3 seconds at a time. The patient was asked to inspire maximally and expire for 1-3 seconds maximally against the closed airway to measure MEP. The average of the values obtained by repeating both measurements three times, was recorded in cmH_2O.[16,17]

Six-Minute Walk Test (6MWT)

Exercise capacity was measured by 6-minute walking test (6MWT). The test was performed in a 30-m corridor in accordance with the testing guidelines.[18] Heart rate and oxygen saturation values of the subjects were recorded before the test. In addition the severity of dyspnea and leg fatigue was evaluated by asking the subjects according to the Modified Borg Scale. Heart rate, oxygen saturation, severity of dyspnea and leg fatigue were evaluated after the test.

Quality of Life Scale

SF-36 (Short Form 36) questionnaire was developed to evaluate the health-related quality of life of patients. It is a quality of life assessment questionnaire consisting of 8 subscales and 36 questions which are physical function (10 items), social function (2 items), physical role (4 items), emotional role (3 items), pain (2 items), vitality (4 items), mental health (5 items) and general health (5 items). Each sub-scale's questions specific to that scale are scored, calculated with special methods, standardized, and a raw score specific to that scale is obtained. Scores range from 0 to 100 for each subscales, and higher scores indicate better function.[19]

BASFI

The BASFI (Bath Ankylosing Spondylitis Functional Index) scale was used to evaluate the functionality of the patients at home and work during the day. BASFI questionnaire, which measures the functional capacity of patients with AS in the previous week, consists of 8 questions about daily activities and 2 questions that evaluate the patient's ability to cope with daily life. The patients are asked to mark the level of difficulty they have while performing the tasks specified in the questionnaire on the 10 cm VAS and a value varying between 0-10 is obtained by calculating the BASFI score by taking the average score from 10 questions.[20]

Statistical Analyses

The SPSS version 22.0 (SPSS Inc., Chicago, IL) program was used. The data were expressed as the mean and standard deviation. The effect sizes were obtained from cohen's d data. Independent sample t test was applied to analyse the difference in groups. Pearson correlation was performed to determine the relationship between variables. Significance was defined as $p \leq 0.05$ and $p \leq 0.01$

RESULTS AND DISCUSSION

Table 1. Characteristics of the Study Participants (Means ± SD)

Variables	AS (n = 28)	CG (n = 28)	p
Age (years)	41.93 ± 9.49	39.61 ± 10.78	0.396
Gender (F/M)	20/8	20/8	-
Height (cm)	162.89 ± 7.66	167.25 ± 7.02	**0.031**
Weight (kg)	71.86 ± 13.99	73.11 ± 15.89	0.756
BMI (kg/m^2)	26.93 ± 5.32	25.95 ± 4.80	0.471
Disease duration (years)	8.50 ± 9.08	NA	-
Exercise frequency (day/week)	4.25 ± 1.48	2.00 ± 0.76	**0.001**
Exercise duration (minutes)	41.67 ± 18.63	55.00 ± 18.52	0.133
BASFI	2.65 ± 2.26	NA	-
Smoking (n)			
Current smoker	3	3	-
Lifelong non-smoker	17	18	-
Ex-smoker	8	7	-
Chest Expansion (cm)			
Axillary	4.00 ± 2.18	NA	-
Epigastric	4.58 ± 3.08	NA	-
Subcostal	4.23 ± 2.38	NA	-

SD, standard deviation; BMI, body mass index; BASFI, bath ankylosing spondylitis functional index; AS, patient group with ankylosing spondylitis; CG, control group; NA, not applicable

The descriptive information of the subjects is presented in Table 1.

Table 2. Comparison of Pulmonary Function, MIP, MEP Measurements between Patients with AS and Control Group

	AS (n = 28)	CG (n = 28)		95% CI	
Variables	Mean ± SD	Mean ± SD	ES	LB	UB
FVC (L)	3.04 ± 0.76	3.48 ± 1.13	-0.46	-0.96	0.08
FEV1 (L)	2.09 ± 0.74[a]	2.62 ± 0.89	-0.65	-0.97	-0.09
FEV1/FVC (%)	69.23 ± 19.37	76.63 ± 15.08	-0.43	-16.71	1.89
MIP (cmH_2O)	51.54 ± 23.54	58.46 ± 17.46	-0.33	-18.03	4.17
MEP (cmH_2O)	60.00 ± 24.79	67.00 ± 25.43	-0.28	-20.45	6.45

[a] Significant difference between AS and CG groups; FVC, forced vital capacity; FEV1, forced expiratory volume in one second; MIP, maximal inspiratory pressure; MEP, maximal expiratory pressure; SD, standard deviation; AS, patient group with ankylosing spondylitis; CG, control group

Although the mean values of respiratory functions and respiratory muscle strength of the control group were higher than the patient group, a significant difference was observed only in the FEV1 value (es = -0.65; 95% CI = -0.97 to -0.09).

Table 3. Comparison of 6MWT and 6MWT Vital Values between Patients with AS and CG

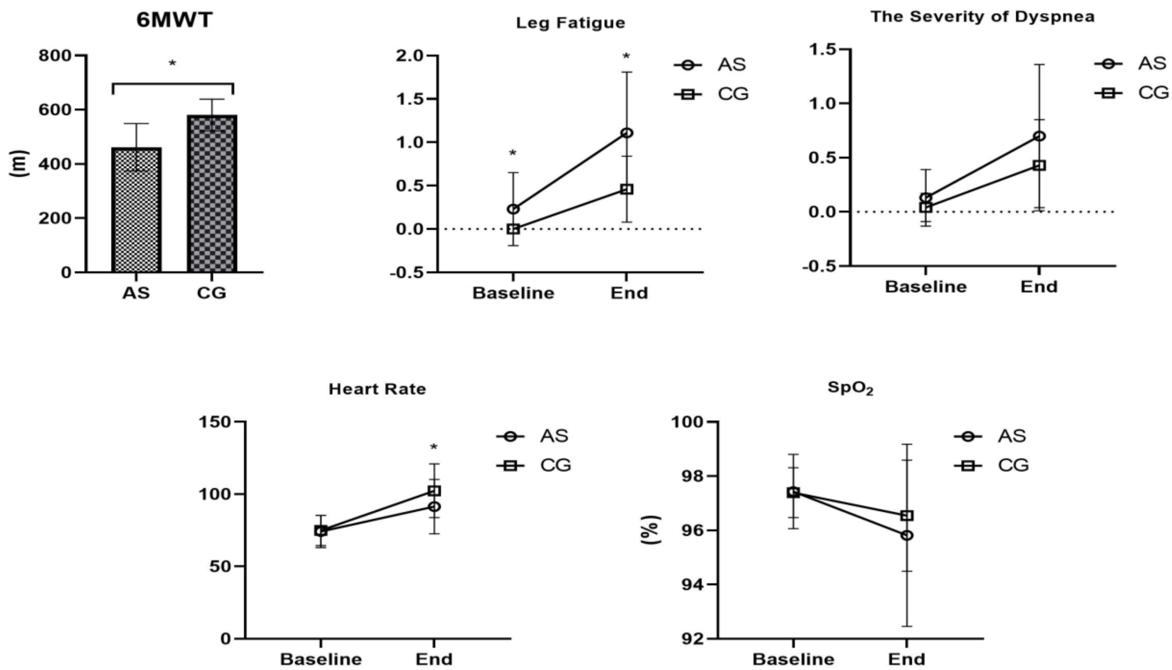
	AS (n = 28)	CG (n = 28)		95% CI	
Variables	Mean ± SD	Mean ± SD	ES	LB	UB
6MWT (m)	461.83 ± 87.50[a]	580.94 ± 58.30	-1.60	-158.94	-79.27
The Severity of Dyspnea					
Baseline	0.13 ± 0.26	0.04 ± 0.13	0.44	-0.02	0.20
End	0.70 ± 0.66	0.43 ± 0.42	0.49	-0.03	0.57
Leg Fatigue					
Baseline	0.23 ± 0.42[a]	0.00 ± 0.00	0.77	0.07	0.39
End	1.11 ± 0.70[a]	0.46 ± 0.38	1.15	0.34	0.95
Heart Rate (beats/minute)					
Baseline	74.21 ± 11.09	74.89 ± 10.48	-0.06	-6.46	5.10

Table 3. (Continued)

End	91.39 ± 18.78[a]	102.36 ± 18.54	-0.59	-20.96	-0.97
SpO_2 (%)					
Baseline	97.43 ± 1.37	97.39 ± 0.92	0.03	-0.59	0.66
End	95.82 ± 3.36	96.54 ± 2.05	-0.26	-2.20	0.77

[a] Significant difference between AS and CG groups; 6MWT six-minute walk test; SpO_2, pulsed oxygen saturation; SD, standard deviation; AS, patient group with ankylosing spondylitis; CG, control group; ES, effect size; LB, lower bound; UB, upper bound

Vital signs of patient and control groups before and after 6MWT were compared. Accordingly, significant difference was obtained in 6MWT (es = -1.60; 95% CI = -158.94 to -79.27), leg fatigue before (es = 0.77; 95% CI = 0.07 to -0.39) and after 6 min test (es = 1.15; 95% CI = 0.34 to 0.95) and heart rate after 6 min test (es = -0.59; 95% CI = -20.96 to -0.97) values (Table 3).



**Significant difference betweeen AS and CG groups;*

Figure 1. Comparison of 6MWT and 6MWT vital values between patients with AS and control group

Comparison of 6MWT and 6MWT vital values is presented in figure 1.

Table 4. Correlation of Pulmonary Function, MIP, MEP Measurements with BASFI, 6MWT, Chest Expansion, Quality of Life Parameters in Patients With AS (r)

Variables	FVC	FEV1	FEV1/FVC	MIP	MEP
BASFI	-0.305	-0.322	-0.126	-0.346	-0.476[a]
6MWT (m)	0.620[b]	0.482[b]	0.053	0.538[b]	0.502[b]
Chest Expansion (cm)					
Axillary	0.602[b]	0.264	-0.229	0.477[a]	0.410[a]
Epigastric	0.282	0.006	-0.168	0.207	0.347
Subcostal	0.601[b]	0.406[a]	-0.008	0.414[a]	0.584[b]

Table 4. (Continued)

Quality of Life (SF-36)					
Physical Function	0.274	0.320	0.160	0.403[a]	0.502[b]
Physical Role	0.640[b]	0.497[b]	0.047	0.525[b]	0.286
Emotional Role	0.151	0.201	0.144	0.219	-0.081
Vitality	0.310	0.255	0.070	0.264	-0.068
Mental Health	0.198	0.223	0.119	0.230	0.022
Social Function	0.389[a]	0.318	0.060	0.394[a]	0.150
Pain	0.266	0.229	0.038	0.308	0.288
General Health	0.191	0.140	-0.012	0.082	-0.163

[a] Correlation is significant at the 0.05 level; [b] Correlation is significant at the 0.01 level; AS, patient group with ankylosing spondylitis; CG, control group

A high level of correlation was found between FVC and 6MWT (r = 0.620), physical role (r = 0.640), axillary (r = 0.602) and subcostal (r = 0.601) chest expansion values. Moderate correlations were found between FEV1 and 6MWT (r = 0.482), subcostal chest expansion (r = 0.406), and physical role (r = 0.497) parameters. There was a moderate level of correlation between MIP and 6MWT (r = 0.538), axillary (r = 0.477), subcostal (r = 0.414) chest expansion, physical function (r = 0.403) and, physical role (r = 0.525). Correlation between MIP and social function (r= 0.394) was low. Moderate level of correlations were found between the other respiratory muscle variable MEP and 6MWT (r = 0.502), axillary (r = 0.410) and subcostal (r = 0.584) chest expansion, physical function (r = 0.502) and BASFI score (r = -0.502).

AS is a systemic, chronic, inflammatory and rheumatic disease caused by inflammation of the axial skeleton and sacroiliac joints.[1] Inflammation of the thoracic and costovertebral joints results in gradual fusion and ossification, preventing the mobility of the rib and chest expansion in AS. This situation creates increased dorsal kyphosis, thoracic stiffness, and chest wall motion restriction in some patients.[2,14] This deterioration in musculoskeletal system and respiratory functions seen in patients with AS adversely affects exercise capacity and quality of life.[1]

Therefore we aimed to examine the effects of respiratory problems caused by loss of movement in the chest wall and ankylosis in the thoracic spine joints on chest expansion by evaluating BASFI score, exercise capacity and quality of life, respiratory function tests, respiratory muscle strength and exercise capacity.

Although lung diffusion capacity, blood gases and respiratory compliance values are normal, there is a restrictive type of respiratory dysfunction in patients with AS.[9] We found that the mean values of respiratory functions and respiratory muscle strength were higher in the control group. FEV1 was the only statistically significant parameter (es = -0.65; 95% CI = -0.97 to -0.09). The possible physiological mechanism of the difference in RFTs is that the mechanical contraction caused by the thoracic joint ankyloses leads to decreased lung volume and capacity. Differences in mean values in respiratory muscles are explained by the damage to the respiratory muscles as a result of enthesitis impairing the normal movement of the costae by affecting the costovertebral, costosternal and costochondral joints and inhibiting the expansion of chest.[2,8] It was also stated that it may be caused by the tendency to fibrosis that occurs as a result of inflammatory processes.[5,21]

In this study, the vital signs of patients with AS were lower than the control group. The average of the 6MWT of patients with AS is 461.83 ± 87.50 meters while it was 580.94 ± 58.30 meters in the control group (es = -1.60; 95% CI = -158.94 to -79.27). Studies have emphasized that exercise capacity decreases in individuals with AS.[14] It has been stated that exercise intolerance caused by decreased aerobic capacity in individuals with AS due to impaired musculoskeletal system and respiratory functions.[22,23] In addition, providing oxygen needed for increased metabolism during exercise puts an excessive load on respiratory muscles, due to chest expansion and limitation of movement and this excessive load reaches the maximum level and causes respiratory muscle fatigue.[24,25] Quickly tired respiratory muscles also negatively affect the exercise capacity.[14] Therefore, it has been stated that respiratory muscle endurance and respiratory muscle strength may be the determinants of exercise capacity in patients with AS.[8,24,26]

Respiratory functions and respiratory muscle strength of the patients with AS were associated with BASFI, 6MWT, chest expansion and quality of life parameters (Table 4). The high respiratory parameters show that exercise capacity, chest expansion and quality of life are also elevated. In other words, improved respiratory muscles and functions mean enhanced exercise capacity, chest expansion and quality of life. In addition, although a significant correlation was obtained with BASFI only in MEP value, it is an important finding that there is an inverse correlation in all respiratory parameters because an increase in any of the respiratory values will cause a decrease in the BASFI score. Studies have also found a low negative correlation between respiratory functions and BASFI score.[2,14]

As a result of electromyographic measurements of the diaphragm and intercostal muscles in patients with AS, it was revealed that inspiratory muscle fatigue developed rapidly and respiratory muscle strength decreased due to intercostal muscle atrophy.[23,27] In other words, respiratory muscles that get tired quickly will have a negative effect on BASFI score, exercise capacity, chest expansion and quality of life. In previous studies, it was stated that there is a positive correlation between respiratory functions and chest expansion, exercise capacity and quality of life, and a negative correlation with BASFI.[2,3,5,14,28] All of these research results are similar to our study. In a comparative study conducted on AS patients and healthy individuals, it was stated that there is a correlation between exercise capacity and respiratory functions and thoracic enlargement and functional level in individuals with AS.[14] Cho et al. reported that there was a correlation between chest expansion and respiratory functions in their study conducted on patients with AS.[2] In other studies examining the correlation between respiratory functions and thoracic enlargement, it has been stated that chest shortening and postural deformities such as increased dorsal kyphosis due to joint ankylosis, directly affect respiratory functions and contribute to the reduction of thoracic enlargement.[29,30] Pain, stiffness, morning stiffness and respiratory disturbances experienced in the future affect the functional capacity and quality of life negatively.[1] Many studies have stated that there is a positive correlation between respiratory functions and quality of life variables.[2,14,31]

CONCLUSION AND RECOMMENDATIONS

In conclusion, it has been observed that impairments in respiratory functions negatively affect the exercise capacity of AS patients in addition to the musculoskeletal system problems which deteriorate their competence in daily life activities and thus the quality of life. Exercises that increase respiratory muscle strength and peripheral muscles should be included in the exercise programs to be prepared for patients with AS, and cardiopulmonary exercise programs should also be applied regularly. There is a need for studies investigating the effects of cardiopulmonary exercise programs and isolated exercises that increase inspiratory and expiratory respiratory muscle strength.

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