Research Report

Effects of a Multimodal Exercise Program for People With Ankylosing Spondylitis

Background and Purpose. Few randomized controlled studies have examined the effects of exercise in patients with ankylosing spondylitis (AS). This study investigated the effects of a 12-week, multimodal exercise program in patients with AS. Subjects. A convenience sample of 30 patients with AS (18 male, 12 female), with a mean age of 34.9 years (SD=6.28), participated in the study. Twenty-six subjects were classified as having stage I AS and 4 subjects were classified as having stage II AS according to the modified New York Criteria. Methods. This study was a randomized controlled trial. Subjects were assigned to either a group that received an exercise program or to a control group. The exercise program consisted of 50 minutes of multimodal exercise, including aerobic, stretching, and pulmonary exercises, 3 times a week for 3 months. Subjects in both groups received medical treatment for AS, but the exercise group received the exercise program in addition to the medical treatment. All subjects received a physical examination at baseline and at 12 weeks. The examinations were conducted under the supervision of a physician who specialized in physical medicine and rehabilitation and included the assessment of spinal mobility using 2 methods: clinical measurements (chin-to-chest distance, Modified Schober Flexion Test, occiput-to-wall distance, finger-to-floor distance, and chest expansion) and inclinometer measurements (gross hip flexion, gross lumbar flexion, and gross thoracic flexion). In addition, vital capacity was measured by a physiologist, and physical work capacity was evaluated by a doctorally prepared exercise instructor. Results. The measurements of the exercise group for chest expansion, chin-to-chest distance, Modified Schober Flexion Test, and occiput-to-wall distance were significantly better than those of the control group after the 3-month exercise period. The spinal movements of the exercise group improved significantly at the end of exercise program, but those of the control group showed no significant change. In addition, the results showed that the posttraining value of gross thoracic flexion of the exercise group was significantly higher than that of the control group. Physical work capacity and vital capacity values improved in the exercise group but decreased in the control group. Discussion and Conclusion. In this study, a multimodal exercise program including aerobic, stretching, and pulmonary exercises provided in conjunction with routine medical management yielded greater improvements in spinal mobility, work capacity, and chest expansion. [Ince G, Sarpel T, Durgun B, Erdogan S. Effects of a multimodal exercise program for people with ankylosing spondylitis. *Phys Ther.* 2006;86:924–935.]

Key Words: *Aerobic exercise, Inclinometer, Pulmonary exercise, Spinal mobility, Stretching.*

Gonca Ince, Tunay Sarpel, Behice Durgun, Seref Erdogan

Downloaded from https://academic.oup.com/ptj/article-abstract/86/7/924/2805154 by Cukurova University Library (CU) user on 09 June 2020

Ankylosing spondylitis (AS) is a chronic, systemic, rheumatic disease that is a prototype of seronegative spondyloarthopathies characterized by inflammation, especially at the spinal column. The disease affects the joints of the spinal and peripheral joints such as the shoulder, hip, knee, and ankle. The thoracic vertebrae are affected, and inflammation of the costovertebral, costosternal, and manubriosternal joints causes pulmonary restriction and thoracic pain.[1–3] The vertebrae become ankylotic, leading to limitation of spinal mobility. From the beginning of the early stage of the disease, inflammation of the spinal and extraspinal joints and enthesis frequently lead to limitation of spinal and joint mobility. As a result, people with AS demonstrate inspiratory muscle fatigue during exercise and limited capacity of maximal oxygen.[4,5] These restrictions lead to decreased daily activity and to decreased quality of life in people with AS.[6–8]

A growing body of research reveals that exercise is as crucial as drug treatment in the management of AS.[6,9,10] For example, Dougados et al[2] reported that physical therapy and exercise are necessary adjuncts to pharmacotherapy. Similarly, Karatepe et al[11] found that Bath Ankylosing Spondylitis Functional Index and Dougados Functional Index scores and Bath Ankylosing Spondylitis Metrology Index and Bath Ankylosing Spondylitis Disease Activity Index values showed significant improvements in patients with AS who exercised at home, and this group of patients stopped using nonsteroidal anti-inflammatory drugs. Sturm et al[12] reported that moderate-intensity exercise training with elements of step aerobics can achieve significant and clinically relevant increases in physical work capacity (PWC) in patients with severe chronic heart failure based on dilated cardiomyopathy. Other researchers[13,14] have suggested that physical exercise can be a remedy for restrictions in PWC, spinal and joint mobility, and pulmonary function. Some exercise studies[13,14] have examined the effects of interventions targeted at a specific impairment. This focused approach to rehabilitation limits the potentional gains. The application of a multimodal approach to intervention may lessen reductions and lead to even greater improvements in functional performance. Thus, the aim of our study was to examine the effects of a multimodal exercise program (including aerobic, stretching, and pulmonary exercises) on AS-associated restrictions.

Materials and Methods

Subjects

Out of 35 patients with AS who were referred by their physician for treatment in the Department of Physical Medicine and Rehabilitation of Cukurova University, 30 patients were recruited for, and consented to participate in, the study. Because communication could not be established with 5 patients, these patients were excluded from this study. The remaining 30 patients were diagnosed according to the modified New York criteria for diagnosing AS[15] by a physician who specialized in physical medicine and rehabilitation. The patients were classified as having stage I or stage II AS based on Steinbrocker Function Criteria (stage I—patient performs all usual activities without handicaps; stage II—functional capacity adequate to conduct normal activities despite handicap or discomfort or limited mobility of 1 or more joints).[16–19] The 30 subjects with AS were randomly divided into 2 groups: an exercise group (15 subjects [6 female, 9 male]; 13 subjects with stage I AS and 2 subjects with stage II AS) and a control group (15 subjects [6 female, 9 male]; 13 subjects with stage I AS and 2 subjects with stage II AS). The subjects' age, height, weight, and duration of disease were recorded. There was no significant difference in these values between the groups (Tab. 1). Both groups were informed about the exercises that would be helpful for their illness. However, only the subjects in the exercise group received supervised exercise training. All subjects were examined by the same physician regularly (once a

G Ince, PhD, is Doctor, Sport-Health Division, Department of Physical Education and Sport, Cukurova University, Adana, Turkey (gonca_ince@hotmail.com or gince@cu.edu.tr). Address all correspondence to Dr Ince at Cukurova Universitesi Beden Eğitimi ve Spor Yuksekokulu, Balcalı, Adana, Turkiye.

T Sarpel, MD, is Professor, Department of Physical Therapy and Rehabilitation, Medical Faculty, Cukurova University.

B Durgun, PhD, is Professor, Department of Anatomy, Medical Faculty, Cukurova University.

S Erdogan, MD, is Associate Professor, Department of Physiology, Medical Faculty, Cukurova University.

All authors provided writing, facilities/equipment, and consultation. Dr Ince provided data collection and analysis and clerical support. Dr Ince and Dr Sarpel provided fund procurement and institutional liaisons. Dr Sarpel and Dr Durgun provided concept/idea/research design and project management. Dr Sarpel provided subjects.

This study was supported by the Research Project Unit of Cukurova University, Adana, Turkey (Project No: SBE2002D12).

This article was received January 19, 2005, and was accepted January 31, 2006.

Downloaded from https://academic.oup.com/ptj/article-abstract/86/7/924/2805154 by Cukurova University Library (CU) user on 09 June 2020

Table 1.
Characteristics of Subjects With Ankylosing Spondylitis

Group	Age (y), $\bar{X}$±SD	Height (cm), $\bar{X}$±SD	Body Weight (kg), $\bar{X}$±SD	Disease Duration (y), $\bar{X}$±SD
Exercise (n=15)	33.67±5.15	167.73±7.91	70.267±12.70	8.27±5.71
Control (n=15)	36.13±7.20	166.87±7.84	68.500±9.22	9.79±6.46
Total (N=30)	34.90±6.28	167.3±7.75	69.38±10.90	9.00±6.02
P[a]	.29	.77	.67	.51

[a] Significant difference at $P<.05$.

month), and all subjects were taking nonsteroidal anti-inflammatory drugs and sulfasalazine (2 g daily). After physical examination, pulmonary, PWC, and joint mobility parameters of AS disease were measured. Subjects in the exercise group performed the multimodal exercise program, which lasted 3 months (3 days per week, 50 minutes per session). A doctorally trained exercise instructor from the Department of Physical Therapy, Cukurova University, who had 10 years of experience provided instruction and guided the training under constant supervision of the physician who diagnosed the subjects. The exercise instructor was blinded to physiologic measures.

Exercise Protocol

The multimodal exercise program (Tab. 2) was divided into 3 periods:

1. Warm-up: 10 minutes of step exercises (each motion repeated 10 times) + 5 minutes of stretching exercises.

2. Main period: 20 minutes of step exercises (each motion repeated 10 times).

3. Cool-down: 10 minutes of pulmonary exercises + 5 minutes of stretching exercises.

Aerobic exercises. The prescribed intensity of aerobic exercise training was calculated for the main period using the Karvonen formula[20]:

220 − patient age

= estimated maximum heart rate (HRMx)

HRMx − mean resting heart rate (MRHR) = (C)

The subjects' personal target zones then were calculated:

(C) × .50 = (D), (D + MRHR) × 0.5 = limit number
(C) × .60 = (E), (E + MRHR) × 0.6 = limit number

A metronome (Wittner mechanics metronome*) and the Borg Scale, a measure of perceived exertion,[21] were used to support the Karvonen formula. The metronome was adjusted for indicating the exact tempo of movement to the subjects. The subjects in the exercise group measured their heart rate (HR) (HR per minute = HR within 15 seconds × 4) during the exercise program.[22,23] Because some negative effects of cardiac training associated with training intensity have been reported,[24] we used low-intensity training to avoid any possible cardiac complications that might emerge during the exercise program in our study. In addition to the rating of perceived exertion of the exercise program, the Borg Scale was used to rate exercise intensity[21] at the end of the warm-up and main periods of the exercise program. The 8 step motions (march, tap up-tap down, V step, step touch, turn step, grapevine, grapevine with knee up, and grapevine with leg curl) that were selected were applied easily to both the warm-up and main periods of the exercise program by the subjects in the exercise group. Table 3 shows descriptions of the step aerobic exercises for the exercise group.[25]

Stretching exercises.[26] The subjects performed 14 stretching exercises during the warm-up and cool-down periods: forward and backward head stretch (Fig. 1), sideways head stretch (Fig. 2), chest and shoulders stretch (Fig. 3), deltoid muscle stretch (Fig. 4), triceps muscle stretch (Fig. 5), overhead stretch (Fig. 6), lateral trunk muscle stretch (Fig. 7), arched back stretch (Fig. 8), leg extensor and pelvic flexor stretch (Fig. 9), spinal twist stretch (Fig. 10), paravertebral muscle stretch (Fig. 11), loosen-up stretch (Fig. 12), upper back prayer (Fig. 13), and double knee-to-chest stretch (Fig. 14). Pulmonary exercises also were used during the cool-down period.

Pulmonary exercises.[27] To increase chest expansion, the following pulmonary exercises were applied: (1) twice the normal rate of inspiration through the nose and expiration through the mouth, (2) normal expiration through the nose and normal expiration through the mouth, (3) respiration through the chest and abdomen, and (4) deep breathing and then expiration through the mouth slowly. Resistance exercises for the inspiratory pulmonary muscles were performed while each subject pressed on the chest with his or her hand and breathed strongly.

* Wittner GmbH, PO Box 1464, D-88308 Isny, Germany (http://www.wittner-gmbh.de).

Downloaded from https://academic.oup.com/ptj/article-abstract/86/7/924/2805154 by Cukurova University Library (CU) user on 09 June 2020

Table 2.
Multimodal Exercise Program for Exercise Group of Subjects With Ankylosing Spondylitis

Stretching Exercises	Aerobic Exercises	Pulmonary Exercises
1. Forward and backward head stretch 2. Sideways head stretch 3. Chest and shoulders stretch 4. Deltoid muscle stretch 5. Triceps muscle stretch 6. Overhead stretch 7. Lateral trunk muscle stretch 8. Arched back stretch 9. Leg extensor and pelvic flexor stretch 10. Spinal twist stretch 11. Paravertebral muscle stretch 12. Loosen-up stretch 13. Upper back prayer 14. Double knee-to-chest stretch	1. March 2. Tap up-tap down 3. V step 4. Step touch 5. Turn step 6. Grapevine 7. Grapevine with knee up 8. Grapevine with leg curl	1. To increase chest expansion, the following pulmonary exercises were applied: a. Twice the normal rate of inspiration through the nose and expiration through the mouth b. Normal inspiration through the nose and normal expiration through the mouth c. Respiration through the chest and abdomen d. Deep breathing and then expiration through the mouth slowly 2. Resistance exercises for the inspiratory pulmonary muscles were performed while the subject pressed on the chest with his or her hand and breathed strongly.

Table 3.
Descriptions of Step-Aerobic Exercises for Exercise Group of Subjects With Ankylosing Spondylitis

Step-Aerobic Exercises	Description
1. March	Walk in military manner or with regular paces.
2. Tap up-tap down	Tap up and tap down on the floor. Step forward on the floor with the lead foot. Step forward and tap the floor with your other foot. Step backward with your other foot. Step backward with your lead foot, with biceps muscle curls (elbow should be at side of the trunk with the palms of the hand facing upward). Bring the hands toward the chest by flexing the elbow and return them to the side of the trunk.
3. V step	Step forward on the floor with the left foot with the shoulder breadth. At the same time, adduct left upper extremity by making fist of your hand. Repeat this movement for the right side. Bring the right foot next to other side. Step backward on the floor with the left foot. At the same time, extend and rotate left upper extremity backward. Repeat this movement for the right side. Bring the right foot next to other side.
4. Step touch	Tap up and tap down on the floor side by side (left side-right side) with arms in a U-position (flex your forearm in front of your body). The elbows are on the level of the shoulders, and the palms are facing each other. The hands are formed into fists. Hands and forearms touch lightly in the middle in front of your body.
5. Turn step	Step forward on the floor with the lead foot. Bring other foot on the floor as you turn. Step off with the lead foot. Bring the other foot backward next to the lead foot.
6. Grapevine	Step to the side with the lead foot. Bring the other foot slightly behind and past the lead foot. Step to the side with the lead foot. Bring the other foot next to the lead foot with overhead pull (with arms shoulder level, pull the arms in toward the thighs and then return them overhead).
7. Grapevine with knee up	Grapevine with knee up (left) at the end of the grapevine (step with one foot and lift the opposite knee) with arm rotation (arms are overhead or at level of shoulder). Rotate the arms clockwise and then back to the starting point.
8. Grapevine with leg curl	Grapevine with leg (hamstring muscle) curl. Step with one foot and bring the opposite heel toward your rear until there is tension in the hamstring muscle) and frontal pull (arms shoulder level, pull the arms in toward the body so fists rest on thighs, then return them to the level shoulder).

Downloaded from https://academic.oup.com/ptj/article-abstract/86/7/924/2805154 by Cukurova University Library (CU) user on 09 June 2020

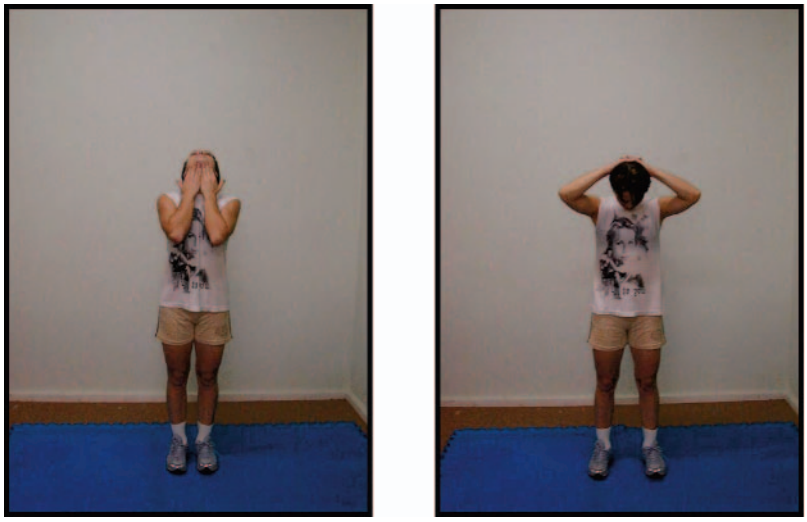


Figure 1.
Forward and backward head stretch: (left) backward head stretch, (right) forward head stretch.

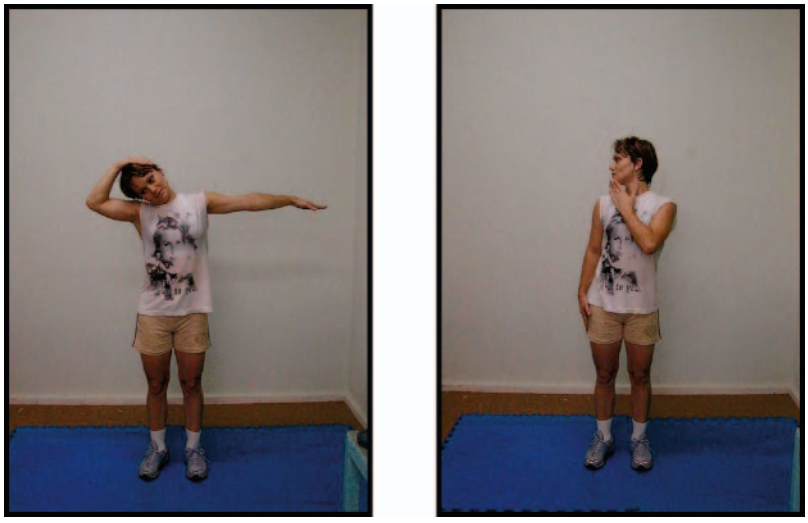


Figure 2.
Sideways head stretch: (left) right sideways head stretch (in flexion), left sideways head stretch not shown; (right) right sideways head stretch (in rotation), left sideways head stretch not shown.

Measurements

The PWC_{170} test[28] was used in the estimation of maximal oxygen intake on a bicycle ergometer (Monark 814[†]). Spinal mobility was measured by inclinometer (Saunders digital inclinometer[‡]) with the subjects in an erect posture and in trunk flexion. For the inclinometric measurements, the curve angle method was used.[29] Measurements were done in 3 different regions: (1) gross hip flexion (sacral midpoint [L5–S1]) (A point), (2) gross lumbar flexion (T12–L1) (B point), and (3) gross thoracic flexion (C7–T1) (C point). The following instructions were given by physician to the subjects during the inclinometric measurements.

Once the inclinometer had stabilized on a flat place and had been zeroed, each subject achieved maximal trunk flexion and the measurement (in degrees) at the A point was recorded. After the inclinometer was set at zero at the A point, it was placed to record the reading (in degrees) at the B point. Finally, after the inclinometer was set at zero at the B point, it was placed to record the reading (in degrees) at the C point. The Saunders digital inclinometer is a portable handheld inclinometer designed to measure posture and mobility of the spine.[30]

We used *chest expansion*, defined as the difference in chest circumference at maximal inspiration and expiration at the level of the fourth intercostal space, as a clinical measure of spinal mobility. We measured occiput-to-wall distance, which is the distance between the occiput and the wall while the person stands with heels and back against a wall and tries to place the occiput against the wall with the chin horizontal. Finger-to-floor distance was assessed by measuring the distance between the fingertips and the floor at maximal flexion of the spine and pelvis while the knees were kept in extension. Chin-to-chest distance was measured by marking the distance between the chin and the jugulum (jugular notch) in maximal flexion of the cervical spine. We used the Modified Schober Flexion Test (MSFT) to measure the increase in the distance between 2 skin marks on the first sacral spinous process (S1) and 10 cm above S1 after maximal forward bending.[31,32] A measuring tape was used in all these measurements. Each measurement was made 3 times by the same physician and exercise instructor.

A computerized spirometer (Spiromet 250[§]) was used to measure vital capacity (VC), which is a reliable index in evaluation of volumetric pulmonary function.[33,34] Vital capacity testing was performed for all subjects by the same physiologist in the exercise physiology laboratory.

[†] Monark Exercise AB, Kroonsvag 1, S-7080 50 Vansbro, Sweden.
[‡] The Saunders Group Inc, 4250 Norex Dr, Chaska, MN 55318-3047.
[§] Spiromet, 1-6-15 Ikenohata, Taito-ku, Tokyo 110 Fukuda Sangyo, Japan.

Downloaded from https://academic.oup.com/ptj/article-abstract/86/7/924/2805154 by Cukurova University Library (CU) user on 09 June 2020

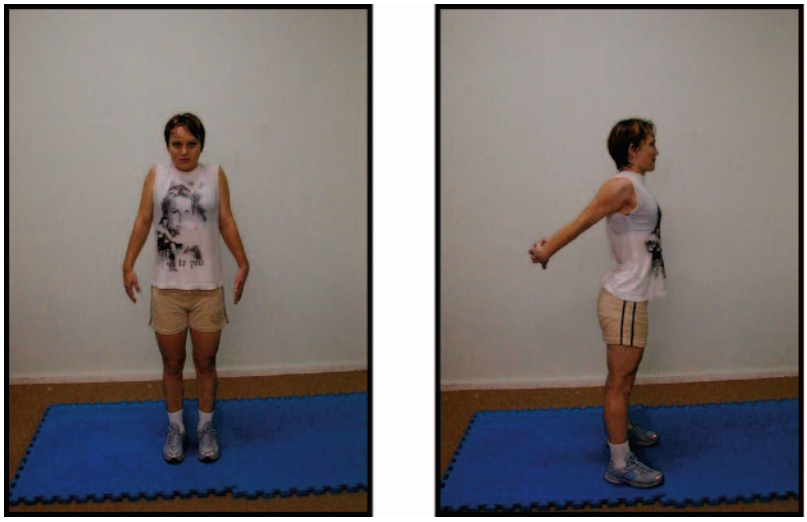


Figure 3.
Chest and shoulders stretch: (left) shoulders stretch, (right) chest stretch.

The spirometer was calibrated by using its own calibration injector every week. All subjects were instructed to rest for 15 minutes prior to the VC testing. Subjects wore a noseclip to prevent air from escaping through the nose. Each subject assumed a standing position, and a mouthpiece, which was attached to a hose connected to the machine, was placed in the subject's mouth. The subject then was asked to breathe in as deeply as possible and to blow into the machine as completely as he or she could. The VC test was performed 3 times, and then the best value was accepted and recorded. The physiologist was blinded to group assignment.

The chronometer was used to record HR during the PWC_{170} test. Heights and weights were measured with a scale, which was calibrated before each measurement.

All of the subjects regularly attended the exercise program. The subjects were asked to rate their perceived exertion during the training exercises, after both the warm-up and main periods, using the Borg Scale.

Data Analysis

All analyses were conducted using the SPSS statistical package, version 10.0.[‖] Descriptive statistics were used for the means and standard deviations. The Student *t* test (2-tailed) and paired-samples *t* test were used for the comparison of groups. The level of significance was accepted as $P<.05$.

Results

The results of this study showed that there were significant differences in the clinical measurements (chin-to-chest distance, occiput-to-wall distance, and MSFT), inclinometric measurements (at the A point [erect position] and C point [flexion]), and in the physiologic measurements (in PWC_{170} and in VC). A comparison of mean values for the spinal range of motion of the exercise and control groups is shown in Table 4.

Significant improvement was found between the beginning and end values of the exercise group for chest expansion ($P=.04$) and finger-to-floor distance ($P=.003$). There were significant increases in chin-to-chest distance ($P=.03$) and occiput-to-wall distance ($P=.02$) in the control group. For the comparison of the groups, there were no significant differences in the baseline values, but significant improvements were found in chest expansion, chin-to-chest distance, occiput-to-wall distance, and MSFT in the exercise group at the end of the exercise program.

Table 5 shows that there were significant improvements in inclinometric measurements, such as at the A point (erect position) ($P=.03$) and C point (flexion) ($P=.001$). For the group comparison, there were no significant differences in the baseline values, but significant improvements were found for the C point ($P=.001$) at the end of the exercise program. Although the PWC_{170} test measurements significantly decreased in the control group at the end of 3 months ($P=.002$), they significantly increased in the exercise group ($P=.001$) (Tab. 6).

At the end of exercise program, VC was decreased in the control group ($P=.004$). In the exercise group, VC was unchanged. A comparison of VC values between the exercise and control groups is presented in Table 7. There were no significant differences in the baseline values for both groups; however, significant increases in VC were observed in the exercise group ($P=.02$) at the end of the exercise program.

Discussion and Conclusion

The findings of this study showed that there were significant improvements in clinical measurements (chest expansion, chin-to-chest distance, occiput-to-wall distance, and MSFT), in inclinometric measurements (at the A point [erect position] and C point [flexion]), and in physiologic measurements (in PWC_{170} and VC values) in patients with AS who participated in a multimodal exercise program. The significant differences between and within groups for chest expansion showed that there were significant improvements. The spinal mobility tests

[‖] SPSS Inc, 233 S Wacker Dr, Chicago, IL 60606.

Downloaded from https://academic.oup.com/ptj/article-abstract/86/7/924/2805154 by Cukurova University Library (CU) user on 09 June 2020



Figure 4.
Deltoid muscle stretch.



Figure 5.
Triceps muscle stretch.



Figure 6.
Overhead stretch.

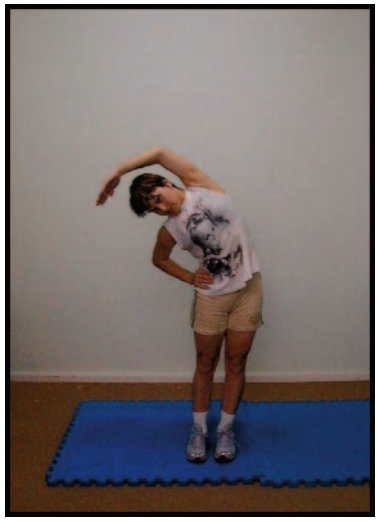


Figure 7.
Lateral trunk muscle stretch.



Figure 8.
Arched back stretch.

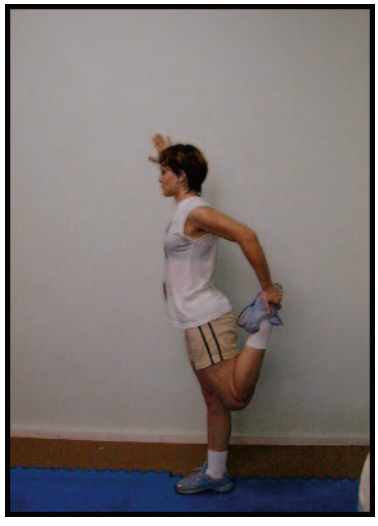


Figure 9.
Leg extensor and pelvic flexor stretch.

Downloaded from https://academic.oup.com/ptj/article-abstract/86/7/924/2805154 by Cukurova University Library (CU) user on 09 June 2020



Figure 10.
Paravertebral muscle stretch.



Figure 11.
Spinal twist stretch.

showed no statistically significant changes. In a study by Wordsworth et al,[9] 11 patients who were given a low dosage of corticotrophin and 10 patients who were given a placebo received postural mobilization exercises for 2 months. The results revealed that functional improvements (in measurements of finger-to-floor distance and wall-to-tragus distance) resulted from the regular exercises. Radiological findings also supported the improvements in lumbar spinal movements. However, there was no improvement in neck movements. Their study also showed that there were no significant differences between the group with the medication and the group with the placebo. The study by Wordsworth et al[9] emphasized that exercise plays as important a role as the traditional drug treatments for AS. In our study, the increases in chin-to-chest distance and occiput-to-wall distance in the control group indicated that exercise is the most important factor for the improvement in spinal mobility, and this finding is in line with that of Wordsworth et al.[9] The other spinal movement tests in our study did not indicate that there were any significant changes.

Viitanen et al[31] reported on 141 patients with AS who participated in a 3- to 4-week exercise program. Improvements in occiput-to-wall distance, finger-to-floor distance, VC, chest expansion, and chin-to-chest distance were observed in these patients. Their results also indicated that the duration of the sickness did not affect the results. Our study also gave support to these findings of the study by Viitanen et al. In addition, Hidding et al[35] showed that the short-term effects of supervised individual therapy on AS were slightly improved mobility, fitness, functioning, and global health. The results of another study by Hidding and colleagues[36] revealed that group physical therapy proved superior to individualized therapy in improving thoracolumbar mobility and fitness.

The comparison of the beginning and 3-month values for spinal movements in both groups showed no significant improvements in the exercise group. Our findings revealed: (1) increases in occiput-to-wall distance and chin-to-chest distance in the control group, (2) significant improvements in chest expansion and finger-to-floor distance in the exercise group, and (3) significant differences between the control and exercise groups in chest expansion, chin-to-chest distance, occiput-to-wall distance, and MSFT at the end of 3 months. Related studies have indicated the following findings. Viitanen et al[31] reported that, after an exercise program of 3 to 4 weeks, improvements were observed in patients' spinal movements, as indicated by MSFT results. However, Heikkila et al[10] reported that the MSFT is not enough for the evaluation of spinal elasticity. They suggested that finger-to-floor distance, chest expansion, thoracolumbar rotation, and lateral flexion also should be used. In our study, the MSFT revealed that there were no significant improvements in AS at the end of the 3-month exercise period. Thus, we assume that the MSFT was not sensitive enough to measure improvements. In addition, our results are in agreement with those obtained by Heikkila et al[10] in terms of inclinometer use for proper evaluation of spinal mobility.

The inclinometric measurements revealed significant differences between the beginning and 3-month exercise results at the A point (in erect position) and at the C point (in flexion) in the exercise group. Significant differences between the control and exercise groups also were found at the C point (in flexion) at the end of the 3-month exercise period. Although there did not seem to be any significant differences between groups at the

Downloaded from https://academic.oup.com/ptj/article-abstract/86/7/924/2805154 by Cukurova University Library (CU) user on 09 June 2020

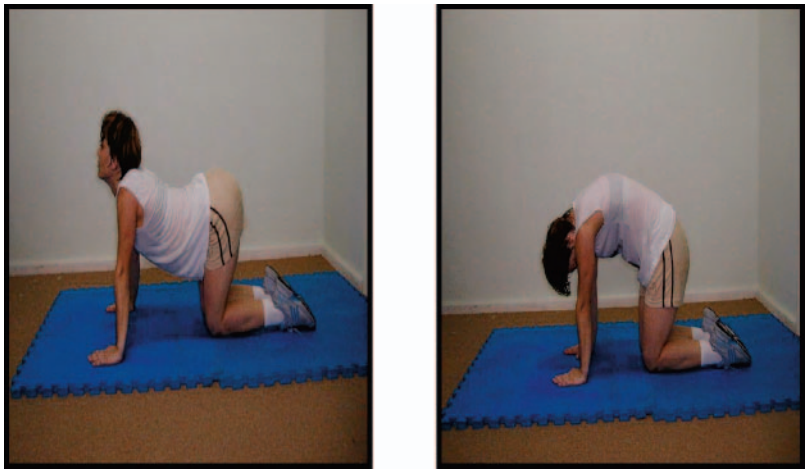


Figure 12.
Loosen-up stretch: (left) downward, (right) upward.



Figure 13.
Upper back prayer.



Figure 14.
Double knee-to-chest stretch.

beginning of our study, the findings of related studies of vertebral flexibility suggest that treatment methods including exercise and physical therapy may increase the quality of life and spinal mobility of people with AS.[37–41]

Related literature[6,7,42,43] emphasized that maximal oxygen consumption and exercise capacity decreased during the course of AS. Sturm et al[12] reported that moderate-intensity exercise training with elements of step aerobics could achieve a significant and clinically relevant increase in PWC in patients with severe chronic heart failure based on dilated cardiomyopathy. Comparison of the beginning PWC_{170} test values between the control and exercise groups in our study did not show any significant differences. The exercise group, however, had significantly higher values than those of the control group at the end of 3 months ($P<.001$).

In this study, the beginning VC measurements of both groups showed no significant differences ($P<.12$), the measurements of exercise group were found to be significantly higher than those of the control group ($P<.05$) after 3 months. When the beginning and 3-month measurements for each group were evaluated, the mean values of the control group at the end of 3 months indicated a significant decrease ($P<.001$), whereas those of the exercise group indicated no significant changes ($P<.72$). Previous studies[42,44] have shown significant reductions in static pulmonary volume (related to chest wall restriction) and decreases in pulmonary volume in people with AS. Thus, it has been shown that limited chest expansion causes decreases in residual volume, VC, maximal respiratory flow rate, total pulmonary capacity, stroke volume, and cardiac output.[45–47]

Miller et al[48] examined the effects of chest-wall restriction on cardiorespiratory function at rest and during exercise in subjects who were healthy. They applied canvas straps around the subjects' thorax and abdomen so that VC was reduced approximately 38%. Our study supported the findings of the study by Miller et al. We found that the volume of VC decreased 7% and chest expansion was reduced 6% in the control group. Fisher et al[4] conducted a study to determine the relationship among restriction of chest expansion, limitation of lung function, and PWC or exercise tolerance in 33 patients with AS. The results of their study suggested that patients who performed a modest amount of exercise regularly could maintain a satisfactory PWC despite very restricted spinal and chest wall mobility. They recommended that

Downloaded from https://academic.oup.com/ptj/article-abstract/86/7/924/2805154 by Cukurova University Library (CU) user on 09 June 2020

Table 4.
Comparison of Control and Exercise Groups of Subjects With Ankylosing Spondylitis for Physical Examination Tests[a]

	Control Group			Exercise Group			Both Groups
Physical Examination Tests	**Baseline (cm)**	**After 3 Months (cm)**	**Within-Group *P***	**Baseline (cm)**	**After 3 Months (cm)**	**Within-Group *P***	**Between-Groups *P***
CE	1.87±0.94	1.77±1.67	NS	2.40±1.38	3.23±1.60	.04	.05
CCD	3.68±1.39	4.38±1.63	.03	2.97±1.51	2.50±1.73	NS	.01
FFD	18.70±14.46	18.07±14.74	NS	18.13±16.16	14.67±16.55	.003	NS
OWD	5.83±3.48	6.79±3.27	.02	4.48±3.21	4.23±3.27	NS	.02
MSFT	12.91±1.81	12.48±1.77	NS	13.63±1.74	13.83±1.62	NS	.02

[a] Values are mean±SD. There were no significant differences in the baseline values between groups. NS=not significant, significant difference at $P<.05$. CE=chest expansion, CCD=chin-to-chest distance, FFD=finger-to-floor distance, OWD=occiput-to-wall distance, MSFT=Modified Schober Flexion Test.

Table 5.
Comparison of the Control and Exercise Groups of Subjects With Ankylosing Spondylitis for Inclinometric Measurements of Spinal Range of Motion[a]

	Control Group			Exercise Group			Both Groups
Spinal Range of Motion Measured With Inclinometer	**Baseline (°)**	**After 3 Months (°)**	**Within-Group *P***	**Baseline (°)**	**After 3 Months (°)**	**Within-Group *P***	**Between-Groups *P***
A point (erect position)	13.60±8.69	12.47±7.09	NS	15.40±9.27	11.60±7.39	.03	NS
A point (flexion)	74.67±15.84	74.60±15.81	NS	67.07±17.80	68.00±17.90	NS	NS
B point (erect position)	12.40±6.84	11.47±6.65	NS	9.67±6.83	9.07±6.81	NS	NS
B point (flexion)	6.13±3.54	5.60±3.98	NS	5.47±4.64	6.33±4.86	NS	NS
C point (erect position)	41.80±15.38	40.93±13.78	NS	35.00±12.90	35.27±13.80	NS	NS
C point (flexion)	75.87±15.27	69.00±14.74	NS	80.33±10.77	87.60±13.30	.001	.001

[a] Values are mean±SD. There were no significant differences in the baseline values between groups. NS=not significant, significant difference at $P<.05$.

Table 6.
Comparison of Mean Values for PWC_{170} Test Between Control and Exercise Groups of Subjects With Ankylosing Spondylitis[a]

Measurements of PWC_{170} Tests of Groups	**Control Group PWC_{170} Test (W/kg), $\bar{X}$±SD**	**Exercise Group PWC_{170} Test (W/kg), $\bar{X}$±SD**	***P***
Baseline	1.78±0.62	1.57±0.31	NS
After 3 mo	1.56±0.60	2.25±0.61	.004
P	.002	.001	

[a] There were no significant differences in the baseline values between groups. NS=not significant, significant difference at $P<.05$.

Table 7.
Comparison of Percentage of Predicted Values for Vital Capacity (VC) Between Control and Exercise Groups of Subjects With Ankylosing Spondylitis[a]

Measurements of VC	**Control Group VC (% Predicted), $\bar{X}$±SD**	**Exercise Group VC (% Presdicted), $\bar{X}$±SD**	***P***
Baseline	81.77±11.30	88.53±11.94	NS
After 3 mo	76.05±14.60	89.29±14.96	.02
P	.004	NS	

[a] There were no significant differences in the baseline values between groups. NS=not significant, significant difference at $P<.05$.

Downloaded from https://academic.oup.com/ptj/article-abstract/86/7/924/2805154 by Cukurova University Library (CU) user on 09 June 2020

patients with AS should be encouraged to maintain cardiorespiratory fitness as well as spinal mobility. Our study showed that multimodal exercises enhance the quality of life of patients with AS. However, we suggest that pyschometric testing should be done to determine patient satisfaction. A limitation of our study is that data were not available on reliability and validity for each instrument used in the study.

In conclusion, an aerobic, stretching, and pulmonary exercise program for a 3-month period led to the improvement of spinal movements, VC volume, and PWC. Therefore, we conclude that the management program for patients with AS should include multimodal exercises. Further research is needed to determine whether the interruption of this exercise program for a long period affects the prognosis of patients with AS.

References

1 Braun J, Heijde VD. Imaging and scoring in ankylosing spondylitis. *Best Prac Res Clin Rheumatol.* 2002;16:573–604.

2 Dougados M, Dijkmans B, Khan MA, et al. Conventional treatments for ankylosing spondylitis. *Ann Rheum Dis.* 2002;61:40–50.

3 Tutuncu Z. Ankylosing spondylitis. UCSD Center for Innovative Therapy Newsletter, Spring 2002. Available at: http://cit.ucsd.edu/level2/forphys/spring2002.pdf.

4 Fisher LR, Cawley MI, Holgate ST. Relation between chest expansion, pulmonary function, and exercise tolerance in patients with ankylosing spondylitis, England. *Ann Rheum Dis.* 1990;49:921–925.

5 Carter R, Riantawan P, Banham SW, Sturrock RD. An investigation of factors limiting aerobic capacity in patients with ankylosing spondylitis. *Respir Med.* 1999;93:700–708.

6 Dougados M, Heijde VD. Ankylosing spondylitis: how should the disease be assessed? *Best Prac Res Clin Rheumatol.* 2002;16:605–618.

7 Khan A. Spondyloarthropathies, ankylosing spondylitis: clinical features. In: Klippel JH, Dieppe PA, eds. *Rheumatology.* 2nd ed. London, United Kingdom: Mosby, Times Mirror International Publishers Ltd; 1998: chap 16.

8 Ward MM, Kuriz S. Risk factors for work disability in patients with ankylosing spondylitis. *J Rheumatol.* 2001;28:315–321.

9 Wordsworth BP, Pearcy MJ, Mowat AG. In-patient regime for the treatment of ankylosing spondylitis: an appraisal of improvement in spinal mobility and the effects of corticotrophin. *Br J Rheumatol.* 1984;23:39–43.

10 Heikkila S, Viitanen JV, Kautiainen H, Kauppi M. Sensitivity to change of mobility tests: effect of short-term intensive physiotherapy and exercise on spinal, hip, and shoulder measurements in spondyloarthropathy. *J Rheumatol.* 2000;27:1251–1256.

11 Karatepe AG, Akkoc Y, Akar S, et al. The Turkish versions of the Bath Ankylosing Spondylitis and Dougados Functional Indices: reliability and validity. *Rheumatol Int.* 2005;25:612–618.

12 Sturm B, Quittan M, Wiesinger GF, et al. Moderate-intensity exercise training with elements of step aerobics in patients with severe chronic heart failure. *Arch Phys Med Rehabil.* 1999;80:746–750.

13 Uhrin Z, Kuzis S, Ward MM. Exercise and changes in health status in patients with ankylosing spondylitis. *Arch Intern Med.* 2000;160:2969–2975.

14 Lim H J, Moon YI, Lee MS. Effects of home-based daily exercise therapy on joint mobility, daily activity, pain, and depression in patients with ankylosing spondylitis. *Rheumatol Int.* 2005;25:225–229.

15 Van der Linden S, Valkenburg HA, Cats A. Evaluation of diagnostic criteria for ankylosing spondylitis: a proposal for modification of the New York criteria. *Arthritis Rheum.* 1984;27:361–368.

16 Swezey RL. Rehabilitation medicine and arthritis. In: McCarty DJ, ed. *Arthritis and Allied Conditions: A Textbook of Rheumatology.* 11th ed. Philadelphia, Pa: Lea & Febiger; 1989:799–800.

17 Schroecksnadel K, Kaser S, Ledochowski M, et al. Increased degradation of tryptophan in blood of patients with rheumatoid arthritis. *J Rheumatol.* 2003;30:1935–1939.

18 Hochberg MC, Chang RW, Dwosh I, et al. The American College of Rheumatology 1991 revised criteria for the classification of global functional status in rheumatoid arthritis. *Arthritis Rheum.* 1992;35:498–502.

19 Steinbrocker O, Traeger CH, Battermann RC. Therapeutic criteria in rheumatoid arthritis. *JAMA.* 1949;140:659–662.

20 Karvonen MJ, Kentala E, Mustala O. The effects of training on heart rate; a longitudinal study. *Ann Med Exp Biol Fenn.* 1957;35:307–315.

21 Champs L, O'Neill ME, Cooper KA, et al. Accuracy of Borg's Ratings of Perceived Exertion in the prediction of heart rates during pregnancy. *Br J Sports Med.* 1992;26:121–124.

22 Omiya K, Itoh H, Osada N, et al. Impaired heart rate response during incremental exercise in patients with acute myocardial infarction and after coronary artery bypass grafting evaluation of coefficients with Karvonen's formula. *Jpn Circ J.* 2000;64:851–855.

23 Saiki S, Sato T, Hiwatari M, et al. Relation between changes in serum hypoxanthine levels by exercise and daily physical activity in the exercise and daily physical activity in the elderly. *Tohoku J Exp Med.* 1999;188:71–74.

24 Ferrand-Guillard C, Ledermann B, Kotzki N. et al. Is it necessary to rehabilitate coronary artery disease patients based on ventilatory threshold? *Ann Readapt Med Phys.* 2002;45:204–215.

25 Barteck O. *All Around Fitness.* Neue Stalling, Oldenburg, Germany: Könemann Verlagsgesellschaft MbH; 1999:130–132, 136, 152.

26 Michel F, Parratte B, Toussirot E, et al. Reeducation de la spondylarthrite ankylosante aspects pratiques. *Rhumato Reeducation Synovial.* November 2000:19–26.

27 Back JR. Rehabilitation of the patient with respiratory dysfunction. In: Delisa JA, ed. *Rehabilitation Medicine Principles and Practice.* Philadelphia, Pa: Lippincott-Raven Publishers; 1998:1359–1383.

28 Committee of Experts on Sports Research Handbook for the Eurofit Tests of Physical Fitness. *Bicycle Ergometer Test (PWC_{170}).* Rome, Italy: Edigraf Editoriale Grafica; 1988;99:30–39.

29 Saunders HD. *Saunders Digital Inclinometer User's Guide.* Chaska, Minn: The Saunders Group Inc; 1998:5–19.

30 Borsa PA, Timmons MK, Sauers EL. Scapular-positioning patterns during humeral elevation in unimpaired shoulders. *J Athl Train.* 2003;38:12–17.

31 Viitanen JV, Lehtinen K, Suni I, Kautiainen H. Fifteen months' follow-up of intensive inpatient physiotherapy and exercise in ankylosing spondylitis. *Clin Rheumatol.* 1995;14:413–419.

32 Roberts NW, Liang MH, Pallozzi LM, Daltroy LH. Effects of warming up on reliability of anthropometric techniques in ankylosing spondylitis. *Arthritis Rheum.* 1988;31:549–552.

33 Ganong WF. *Review of Medical Physiology.* 21st ed. New York, NY: McGraw-Hill Inc; 2003:650–653.

Downloaded from https://academic.oup.com/ptj/article-abstract/86/7/924/2805154 by Cukurova University Library (CU) user on 09 June 2020

34 Berne RM, Levy MN, *Physiology*. 4th ed. St Louis, Mo: Mosby; 1998:529.

35 Hidding A, Linden VD, Vitte LD. Therapeutic effects of individual physical therapy in ankylosing spondylitis related to duration of disease. *Clin Rheumatol*. 1993;12:334–340.

36 Hidding A, Linden VD, Boers M, et al. Is group physical therapy superior to individualized therapy in ankylosing spondylitis? A randomized controlled trial. *Arthritis Care Res*. 1993;6:117–125.

37 Calin A, Kaye B, Sternberg M, et al. The prevalence and nature of back pain in an industrial complex: a questionnaire and radiographic and HLA analysis. *Spine*. 1980;5:201–205.

38 Calin A, Porta J, Fries JF, Schurman DJ. Clinical history as a screening test for ankylosing spondylitis. *JAMA*. 1977;237:2613–2614.

39 Corrigan B, Kannangra S. Rheumatic disease: exercise or immobilization? *Aust Fam Physician*. 1978;7:1007–1014.

40 Iobhan S, Gordon T, Andrei C. The effect of a home-based exercise intervention package on outcome in ankylosing spondylitis: A randomized controlled trial. *J Rheumatol*. 2002;29:763–766.

41 Kantor T. Arthritis and related disorders: ankylosing spondylitis. In: Goodgold J, ed. *Rehabilitation Medicine*. St Louis, Mo: Mosby; 1988: 198–199.

42 Elliott CG, Hill TR, Adams TE, et al. Exercise performance of subjects with ankylosing spondylitis and limited chest expansion. *Bull Eur Physiopathol Respir*. 1985;21:363–368.

43 O'Connor S, McLoughlin P, Gallagher CG, Harty HR. Ventilatory response to incremental and constant work load exercise in the presence of a thoracic restriction. *J Appl Physiol*. 2000;89:2179–2186.

44 Sahin G, Calikoglu M, Ozge C, et al. Respiratory muscle strength but not BASFI score relates to diminished chest expansion in ankylosing spondylitis. *Clin Rheumatol*. 2004;23:199–202.

45 Forkert L. Effect of regional chest wall restriction on regional lung function. *J Appl Physiol*. 1980;49:655–662.

46 Harty HR, Corfield DR, Schwartzstein RM, Adams L. External thoracic restriction, respiratory sensation and ventilation during exercise in men. *J Appl Physiol*. 1999;85:1142–1150.

47 Klineberg PL, Rehder K, Hyatt RE. Pulmonary mechanics and gas exchange in seated normal men with chest restriction. *J Appl Physiol*. 1981;51:26–32.

48 Miller JD, Beck KC, Jorner MJ, et al. Cardiorespiratory effects of inelastic chest wall restriction. *J Appl Physiol*. 2002;92:2419–2428.

Downloaded from https://academic.oup.com/ptj/article-abstract/86/7/924/2805154 by Cukurova University Library (CU) user on 09 June 2020