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Are swimming or aerobic exercise better than conventional exercise in ankylosing spondylitis patients? A randomized controlled study

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Aim. **The aim of the study was to compare the effects of conventional exercise (CE), swimming and walking on the pulmonary functions, aerobic capacity, quality of life, Bath indexes and psychological symptoms in patients with ankylosing spondylitis (AS).**

Methods. **Forty-five patients were randomised into either swimming (group 1), walking (group 2), CE group (group 3). Patients in Group 1 performed CE and swimming, patients in Group 2 performed CE and walking and patients in Group 3 performed CE only. Exercise sessions were performed three times a week for a period of six weeks. Patients were assessed before and after the rehabilitation program, with respect to, pulmonary function test (forced vital capacity [FVC, mL], forced expiration volume in one second [FEV1, mL], FEV1/FVC (%) and vital capacity [VC, mL]), maximal oxygen uptake (p$\dot{V}O_2$), 6-minute walking test (6MWT), Bath Ankylosing Spondylitis Functional Index, Bath Ankylosing Spondylitis Disease Activity Index, Bath Ankylosing Spondylitis Metrology Index, Nottingham Health Profile and Beck Depression Inventory.**

Results. **There were significant increases in p$\dot{V}O_2$ and 6MWT after treatment in Groups 1 and 2 (P<0.05). FeV1, FVC and VC improved significantly with treatment in all three groups (P<0.05). A statistically significant improvement was observed in energy, emotional reaction and physical mobility sub-scores of NHP in three exercise groups after completion of the exercise program (P<0.05).**

Conclusion. **Swimming, walking and CE had beneficial effects on the quality of life and pulmonary functions. Aerobic exercises such as swimming and walking in addition to CE increased functional capacities of patients.**

Key words: Spondylitis, ankylosing - Exercise training - Swimming - Aerobic exercise.

Ankylosing spondylitis (AS) is a chronic inflammatory disease of the axial skeleton with a variable involvement of peripheral joints and non-articular structures.[1] Involvement of axial, peripheral and non-articular structures can cause physical disability in patients with AS. The main clinical characteristics of AS are reduced physical activity, pain, stiffness, sleep disturbances, reduced spinal mobility, and psychological consequences such as depression.[2] The objective of treatment in AS is to reduce morning stiffness, correct postural deformities, increase mobility and improve the psychosocial status of the patients.[3, 4] Despite tremendous progress in the pharmacological therapy of AS, physical therapy and exercise remain essential parts of treatment.[5, 6] It has been shown that

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exercise alleviates pain, increases spinal mobility and functional capacity, better psychological symptoms and improves the quality of life in AS patients.[5]

In AS patients, aerobic exercises such as swimming and walking are recommended in addition to conventional exercises (CE).[5] However, as for many diseases, there are no studies in the literature showing which types of exercises are more effective in patients with AS.

The objective of this study was to compare the effects of CE, swimming and walking on functional capacity, quality of life, Bath Indexes and psychological symptoms.

Materials and methods

Patients diagnosed according to the Modified New York Criteria and aged 18-75 years were allocated into study. They were recruited from the Physical Medicine and Rehabilitation Department of Ege University Hospital in Izmir, Turkey, between 2006-2008.

Subjects were eligible to participate in the program if they knew how to swim, were outpatients without complication, able to understand the content of questionnaire and exercise program. Exclusion criteria were inability or unwillingness to participate in physiotherapy, systemic organic involvement, active peripheral joint involvement, severe comorbidities affecting heart, lung, liver or kidneys and receiving disease modifying drugs other than sulfasalazine or metotheraxate within the four weeks of enrolment, previous usage of TNF alpha blockers (The use of TNF alpha blockers was excluded from the study in order to provide homogeneity in the study and in consideration of the possible effect of TNF alpha on the quality of life).

Additionally, patients who had been exercising regularly during the past six months, were also not included to the study. All patients had exclusively spinal involvement. Patients were clinically stable. All patients treated with sulfasalazine or metotheraxate were on stable dosage for at least six months. None of the patients were on steroid treatment. Medications of the patients were not altered in the course of the study.

Forty-six subjects volunteered to participate in the study. One patient was excluded from the study when diastolic heart failure was diagnosed by echocardiography. A total of 45 subjects were randomly assigned (concealed envelope) to group 1 (swimming exercise and CE exercise), group 2 (walking exercise and CE) and group 3 (CE). Of the initial 45 patients, 8 patients failed to complete the program; two had problems with commuting (one in the group 1, one in group 2), three were unwilling to exercise (one in group 2, two in group 3), two had changes in their prescription (one in group 2, one in group 3), one was unable to get permission from work (one in the group 1). Thirteen patients in Group 1 (mean age: 50.15±12.40 years, female/male ratio: 3/10), 12 patients in Group 2 (mean age: 46.92±13.40 years, female/male ratio: 4/8) and 12 patients in Group 3 (mean age: 48.42±9.47 years, female/male ratio: 3/9) completed the study (Figure 1).

Measurements

Initially, all patients underwent echocardiography to exclude any possible cardiovascular pathology. Transthoracic echocardiography was performed on congestive heart failure patients using Hewlett Packard Sonos 2000 device and 2.5 MHz transducer. Measurements were assessed according to the recommendation of the American Thoracic Society (ATS).[7] Left ventricular ejection fractions (LVEF) were calculated by modified Simpson's method.[6] LVEF, left ventricle end-diastolic diameter, left ventricle end-systolic diameter, left atrial diameter obtained from echocardiogram.

The following assessments were performed for all subjects before and after the exercise program.

Pulmonary function test (PFT)

PFTs were performed on all patients prior to the cardiopulmonary exercise test (Masterscreen CPX, Viasys Health Care, Jaeger, Würzburg, Germany). The forced vital capacity (FVC mL), the forced expiration volume at the first second (FEV1, mL), FEV1/FVC (%) and vital capacity (VC, mL) were recorded for every patient. All the measurements were done in accordance with the ATS criteria.[8]

Functional capacity

Functional capacities of the patients were assessed by cardiopulmonary exercise test and 6-minute walking test.

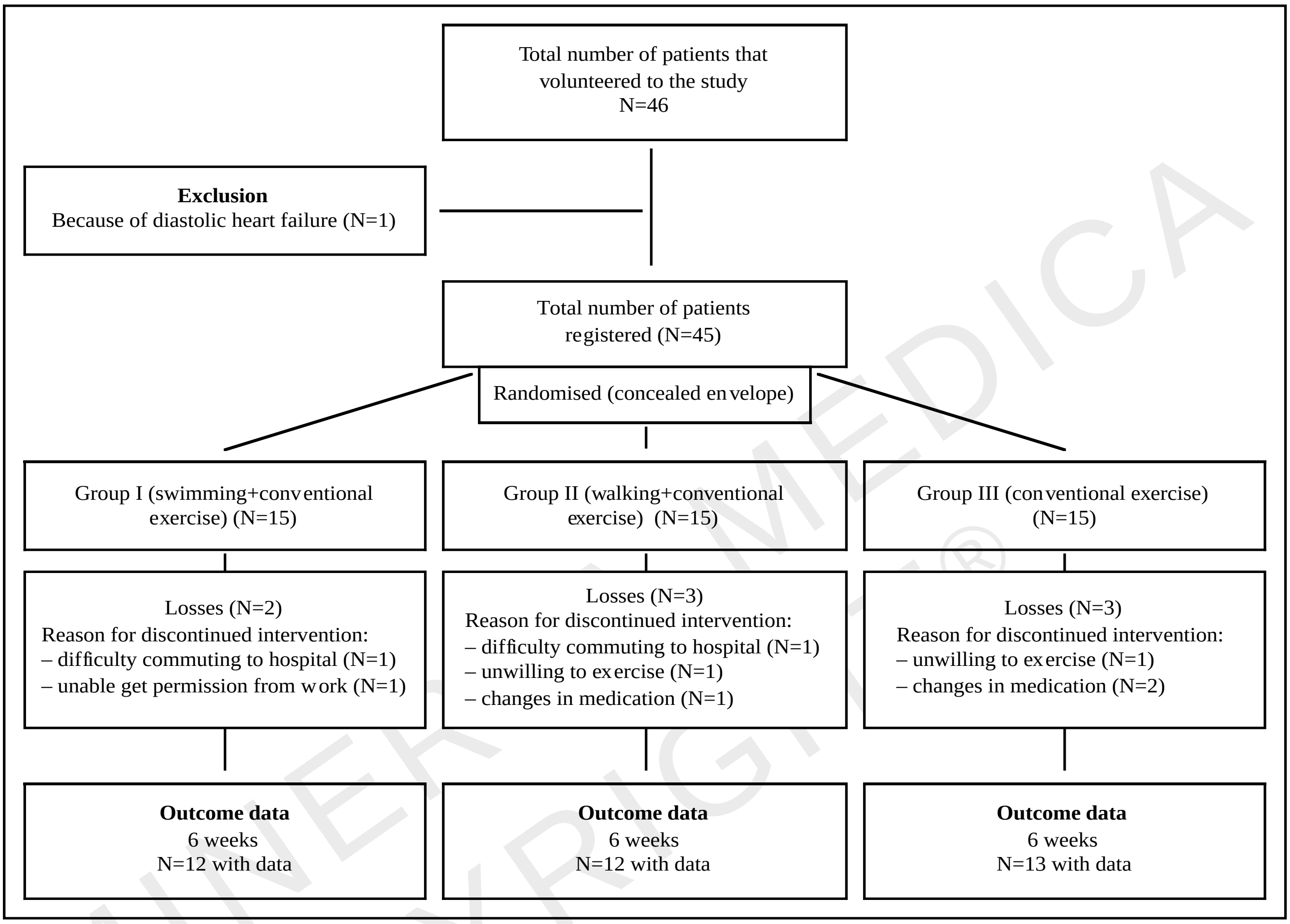

Figure 1.—Flow diagram of the study.

Cardiopulmonary exercise test

The incremental symptom limited cardiopulmonary exercise test was performed on a treadmill, and for every patient the test was conducted by the same investigator (Treadmill model 770 CE). During the testing, the 12-lead electrocardiogram was monitored continuously throughout the test for rhythm, rate and ST-T changes. Blood pressure readings were taken at baseline and at the end of each exercise stage, and during the first five minutes of recovery. The modified Bruce protocol was administered to all patients.[9] Maximal oxygen consumption ($p\dot{V}O_2$) and carbon dioxide production ($\dot{V}CO_2$) were each analyzed breath-by-breath and by calculating the mean values from air expired at 30-sec intervals with the metabolic measurement device (Masterscreen CPX with metabolic card, Viasys Healthcare) during the test. The test was terminated if one of the following occurred: severe angina, limiting symptoms (such as dyspnea, dizziness, leg fatigue, etc.), ventricular tachycardia, conduction abnormalities, ST depression >3 mm and excessive increase (>230 mmHg) or significant drop (>30 mmHg) in systolic blood pressure. The results of exercise electrocardiogram were considered positive according to conventional criteria (1 mm or more of horizontal or downsloping ST-segment depression or elevation of >1 mm in leads without pathologic Q waves for at least 60-80 milliseconds after the J point). The $p\dot{V}O_2$ (mL/kg/min), anaerobic threshold (AT, mL/kg/min) and respiratory exchange ratio (RER) values obtained from the exercise test were recorded.

Six minute walking test (6MWT)

The 6MWT was performed at least four hours before cardiopulmonary exercise test. Participants walked up and down a 20-m hallway for a period of six minutes at their own pace. Patients were permitted to stop and rest and were instructed to continue walking as soon as they felt able to do so. The distance walked by each subject was recorded in meters.[10]

Bath Ankylosing Spondylitis Functional Index (BASFI)

The BASFI consists of eight questions on daily activities and two additional questions that assess patients' ability to cope with everyday life. Each question is answered on 10-cm horizontal visual analog scale (VAS). The VAS has no distinguishing marks except the words easy and impossible at either end of the line to indicate the direction of the severity. The mean of the ten scales gives the BASFI score (0-10), with higher scores indicating more severe impairment.[11, 12]

Bath Ankylosing Spondylitis Disease Activity Index (BASDAI)

The BASDAI is a self-administered questionnaire consisting of six questions relating to the five major symptoms fatigue, spinal pain, joint pain/swelling, areas of localized tenderness, and morning stiffness, measured in terms of both severity and duration. The patients were asked to mark the degree to which they had experienced aforementioned symptoms over the previous week. Each of the first five questions are answered on 10-cm, unmarked, horizontal VAS, except for the words none and very severe on the left and right ends, respectively, while the scale for quantity of morning stiffness is graded every 15 min between 0 h and 2 h. The mean of the two scores on morning stiffness is calculated. The total BASDAI score is obtained by converting the last score for the overall index (0-50) to a 0-10 scale.[13, 14]

Bath Ankylosing Spondylitis Metrology Index (BASMI)

The BASMI is composed of five measurements: cervical rotation tragus-to-wall distance lumbar lateral flexion modified Schobers distance and intermalleolar distance.[14] Each measurement indicates either 0 (mild disease involvement), 1 (moderate disease involvement), or 2 (severe disease involvement) points, resulting in a total BASMI score of 0-10.[15]

In addition to BASMI measurements, chest expansion [15] and finger-to-tip distance [16] were also measured.

The Nottingham Health Profile (NHP)

NHP consists of two parts. Part I contains 38 yes/no items in six dimensions: pain, physical mobility, emotional reactions, energy, social isolation and sleep. Part II contains seven general yes/no questions concerning daily living problems. The two parts may be used independently and part II was not analyzed in this study. Part I is scored using weighted values which give a range of possible scores from zero (no problems at all) to 100 (presence of all problems within a dimension).[17, 18]

Beck Depression Inventory (BDI)

BDI is a 21-item test presented in multiple choice format which purports to measure presence and degree of depression. Responses are made on a four point, minimally-anchored scale, ranging from 0 to 3, with 3 representing the most severe symptoms.[19]

Exercise program

Prior to the start of the program, educational sessions and individual counseling were performed by a physiatrist about AS. All of the patients were trained how to correctly perform the exercises by a physician in physical therapy and rehabilitation. For each of the exercises, participants were provided with simple, step-by-step written instructions with illustrations.

CE: all patients were instructed to perform CE comprised of flexibility exercises for cervical, thoracic and lumbar spine, stretching exercises for the major muscle groups (erector spine, shoulder muscles, hip flexors, hamstrings and quadriceps stretch) and respiratory exercises (pursed-lip breathing, expiratory abdominal augmentation, and synchronization of thoracic and abdominal movement) for 30 minutes, once a day for six days.

In addition to CE, patients in Group 1 were instructed to swim in free-style in a community swimming pool, 30 minutes a day, three times a week for six

TABLE I.—*Comparisons of Groups 1, 2 and 3 with respect to demographic and echocardiographic data.*

	Group 1 (n:13)	Group 2 (n:12)	Group 3 (n:12)
Age (year,mean±SD)	50.15±12.395	46.92±13.399	48.42±9.472
Sex (male) n, (%)	10 (37)	8 (29.6)	9 (33.3)
BMI (kg/m^2) mean±SD	25.81±4.11	26.67±5.18	24.30±3.78
Duration of disease (year, mean±SD)	20.62±10.10	17.42±12.43	18.63±7.52
Smoking (packet/year) mean±SD	17.23±22.83	12.36±11.28	8.70±12.66
Accompanying disease (n, %)			
— Hypertension	2 (28.6)	4 (57.1)	1 (14.3)
— Diabetes	1 (100)	0 (0)	0 (0)
Echocardiogram (mean±SD)			
— LVEF	57.06±1.05	58.02±0.98	58.47±2.04
— LVEDD (mm)	4.09±1.02	3.86±0.67	3.27±0.57
— LVESD (mm)	3.48±0.77	3.20±0.96	4.32±0.78
— LA (mm)	3.35±0.49	3.29±0.29	3.22±0.24
Drugs (n, %)			
— SLZ	2 (33.33)	3 (50)	1 (16.6)
— MTX	1 (16.67)	2(33.33)	3 (50)
— SLZ+MTX	0 (0)	1 (33.33)	2 (66.66)

BMI: Body mass index kg/m^2, LVEF: left ventricle ejection fraction, LVEDD: left ventricle end-diastolic diameter, LVESD: left ventricle end-systolic diameter, LA: left atrial diameter, SLZ: salazopirin, MTX: methotrexate ,*p<0.05.

weeks. The study was performed in the swimming pool of the physiotherapeutic facilities in Izmir. The water temperature was 32 °C throughout the study. Sessions comprised of 10 min warm-up and 5 min stretching followed by 30 min of swimming at a moderate intensity (60-70% heart rate [HR] reserve - 12 beats/minute), 10 min cooling down and 5 min stretching. Mean training HR, measured by HR monitor (Polar Edge, Polar Electro Oy, Finland), was used to determine the training intensity.

Patients in Group 2 performed 30 minutes of walking a day, three times a week for six weeks in addition to CE. Walking exercise was performed at 60-70% of the $p\dot{V}O_2$, at a level of 13-15 on the Borg scale and 60-70% heart rate reserve. The participants wore the Polar Beat watch during each walking session and monitored their heart rate.

Patients in Group 3 performed only CE.

This study was approved by the local ethics committee of our institution and informed consent forms were obtained from all patients who participated.

Statistical analyses

Data were introduced in the SPSS statistical package, version 16.0. The Kolmogorov-Smirnov test was used to test for the normality of the distribution of the data. Repeated measures analysis of variance (ANOVA) was used to assess the difference in normally distributed data between before and after treatment. One-way ANOVA was used to pre-treatment assessment of variables of which interaction was significant. Differences between before and after treatment were tested by paired t test separately for each group. Analysis of co-variance was used to compare groups after treatment.

Differences in not-normally distributed variables between groups before the treatment were tested by Kruskal Wallis and Mann Whitney U tests. Differences between before and after treatment were also tested by the same methods. A P-value below 0.05 was considered to be indicative of statistical significance.

Results

Thirty seven patients have completed the study. Demographic and echocardiographic details of Groups 1, 2 and 3 are presented in Table I. When the exercise groups were compared, no statistically significant differences were found in the demographic and echocardiographic characteristics (p>0.05). Similarly, all three group were comparable with respect to BASMI, thorax expansion, hand-to-floor distance, BASFI, BASDAI, NHP, BDI scores and cardiopulmonary parameters ($p\dot{V}O_2$, AT, RER) and pulmonary function tests

TABLE II.—*Functional disability (BASMI, BASFI, BASDAI), quality of life and depression before and after exercise in groups 1, 2 and 3.*

	Group 1 (n:13)		Group 2 (n:12)		Group 3 (n:12)	
	Pre-E mean±SD	Post-E mean±SD	Pre-E mean±SD	Post-E mean±SD	Pre-E mean±SD	Post-E mean±SD
BASMI	5.15±2.27	4.54±2.07	4.54±2.58	4.18±2.99	3.83±3.75	3.75±2.67
Cervical rotation	48.50±19.27	51.46±19.30	43.86±45.32	45.32±22.42	47.71±19.43	46.88±21.59
Tragus-to-wall distance	19.00±8.23	15.54±4.54	18.54±9.62	17.82±9.18	15.63±4.67	15.63±4.93
Lumbar lateral flexion	8.08±5.18	6.88±2.64	7.73±5.02	8.36±5.82	7.64±6.77	8.38±6.04
Modified Schobers distance	2.39±1.30	2.27±1.05	3.00±1.72	2.77±1.66	3.25±1.53	3.25±2.13
Intermalleollar distance	89.35±23.77	91.46±22.01	92.09±18.16	91.41±23.36	94.88±19.80	97.00±25.11
Chest expansion	3.38±1.09	4.67±2.27*	3.40±1.24	3.85±1.70	4.08±2.24	4.13±2.15
Hand-to-floor distance	20.53±13.97	19.04±12.36	22.27±7.88	20.32±8.76	24.79±10.59	25.25±10.66
BASDAI	2.73±1.93	1.90±1.61	≠2.49±1.68	2.68±2.19	2.65±2.13	2.03±1.86
BASFI	2.34±1.70	1.97±1.24	2.25±1.81	2.25±2.30	2.70±2.52	3.13±2.65
NHP						
— Energy level	25.62±33.74	15.75±31.79*	25.14±27.31	14.98±35.16*	24.83±33.41	14.67±27.39*
— Pain	27.89±32.74	25.00±28.41	25.00±25.62	19.79±26.89	25.75±25.28	21.04±34.32
— Emotional reaction	23.66±20.34	14.81±21.66*	22.11±21.33	12.50±20.81*	24.78±33.62	15.45±33.75*
— Sleep	16.92±29.26	23.07±28.10	12.73±16.18	8.33±13.71	30.00±30.15	24.38±19.60
— Social isolation	4.62±11.98	4.62±11.98	9.09±20.71	6.67±13.03	26.67±34.47	21.88±27.16
— Physical mobility	20.19±21.37	10.08±20.95*	25.00±19.36	16.88±18.56*	27.08±19.82	18.96±22.90*
BDI	6.85±6.52	5.47±4.77	8.50±5.36	9.70±8.59	6.17±10.02	5.00±10.22

BASMI: Bath Ankylosing Spondylitis Metrology Index, BASFI: Bath Ankylosing Spondylitis Functional Index, BASDAI: Bath Ankylosing Spondylitis Disease Activity Index, NHP: The Nottingham Health Profile, BDI: Beck Depression Inventory.
*p<0.05 within groups; #p<0.05 between groups 1 and 2.

(FeV1 [mL], FVC [mL], FeV1/FVC %, VC [mL]) before the onset of the exercise program (P>0.05).

A statistically significant improvement was observed in energy, emotional reaction and physical mobility subscores of NHP in all exercise groups after completion of the exercise program (Table II) (P<0.05). A significant increase in chest expansion with swimming exercise was observed in Group 1 (P<0.05, Table II). Significant increases were found in pVO2 and 6-minute walk test after the treatment in Groups 1 and 2 (Table III, p<0.05). FeV1, FVC and VC improved significantly with treatment in all groups (Table III, p<0.05).

Comparison of the three exercise groups revealed that BASDAI score increased significantly in Group 1 than in Group 3 (p<0.05, Table II). Similarly, 6-minute walk test improved significantly in Group 1 compared to Group 3 (p<0.05).

No significant differences were detected either of the exercise groups with regard to BASMI, hand-to-floor distance, BASFI, BDI, social, sleep and pain subscores of NHP and FeV1/FVC % (P>0.05, Tables II, III).

No complications were observed in any of the groups during the exercises.

Discussion

The present study allowed to find out that pulmonary functions and quality of life improved with exercise in all groups and aerobic capacity increased with swimming and walking. There were no significant differences in pulmonary function tests, functional capacity, quality of life, Bath Indexes and psychological symptoms between three groups.

Pulmonary involvement is the most frequent extra-articular involvement in AS patients. Pulmonary involvement in AS has been demonstrated by plain radiographs in 0-30% of the cases [20] or by high resolution computed tomography in 40-80% of the cases.[21] The psychological status and quality of life of AS patients which are already poor as a result of pain, stiffness and restriction in bodily functions may further deteriorate after pulmonary involvement. Abnormalities in pulmonary functions tests and diffusion tests have been reported in AS patients.[21, 22] Pulmonary abnormalities in AS patients have been attributed to the decrease in chest expansion secondary to ankylosis of costovertebral and costosternal joints.[21] On the other hand, respiratory failure or complain of dyspnea is

TABLE III.—*Cardiopulmonary test results before and after treatment in groups 1, 2 and 3.*

	Group 1 (n:13)		Group 2 (n:12)		Group 3 (n:12)	
	Pre-E mean±SD	Post-E mean±SD	Pre-E mean±SD	Post-E mean±SD	Pre-E mean±SD	Post-E mean±SD
6 MWT (meter)	353.062±82.31	496.25±53.30*≠	400.10±95.62	441.80±110.32*	414.750±86.67	409.08±21.32
p$\dot{V}O_2$ (ml/kg/min)	25.22±6.82	28.73±6.68*	24.60±5.19	27.96±6.04*	23.58±7.05	24.99±6.22
RER	1.01±0.08	1.07±0.07	1.03±0.15	1.03±0.14	1.12±0.01	1.14±0.12
AT(ml/kg/min)	24.48±7.41	22.86±6.03	22.73±5.34	20.30±7.13	19.06±4.27	17.10±2.89
FeV1 (ml)	2.52±0.94	2.61±0.98*	2.56±0.91	2.60±1.02*	3.01±1.07	3.18±1.19*
FVC (ml)	3.06±1.09	3.30±1.90*	3.11±1.07*	3.28±1.18*	3.65±1.26*	3.82±1.25
FeV1/FVC (%)	80.27±12.67	78.02±11.25	82.46±8.07	78.68±6.04	82.07±8.72	82.84±6.79
VC (ml)	3.22±1.06	3.42±1.13*	3.23±1.04*	3.33±1.23*	3.81±1.39*	3.96±1.33

*p<0.05 within group; ≠p<0.05 (between groups 1 and 2).
Pre-E: Pre exercise, Post-E: Post exercise, 6MWT: 6-minute walk test, p$\dot{V}O_2$ ml/kg/min: Maximal O_2 consumption, RER: respiratory exchange ratio, AT: anaerobic threshold (ml/kg/min) FVC : forced expiratory vital capacity, FeV : Forced expiratory volume in one second, FeV1/FVC%: The ratio forced expiratory volume in one second to forced vital capacity of the lungs, VC: vital capacity.

very rare among AS patients and, therefore, pulmonary involvement may be overlooked. Similar to the present study, Hart *et al.* measured pulmonary functions before and after exercise and reported improvements in many of their patients.[23] Jossenhans studied 222 patients with AS before and after physiotherapy and found that spirometry remained unchanged despite improvements in chest wall and spinal mobility.[24] In the present study, improvements in pulmonary function tests in all three exercise groups and a further improvement in chest expansion in the swimming group have been noted. Improvements in the pulmonary function tests in all three exercise groups can be explained by the subjects in all groups having performed the same pulmonary exercises and their compliance to the program. Identification of pulmonary involvement in early stages of the disease and prompt initiation of pulmonary rehabilitation is important to prevent functional restriction, reduce psychological symptoms, increase quality of life and avert pulmonary complications that might occur later.[25]

A decrease in functional capacity can be observed in AS patients due to musculoskeletal (axial skeleton deformities, peripheral muscle disorder) or pulmonary impairment.[25] Aerobic capacity can be increased by rehabilitation programs performed regularly.[26, 27] In our study, significant improvements in aerobic capacity, assessed by cardiopulmonary function test and 6MWT, were observed in patients who were given swimming and walking exercises. Although swimming is the most recommended exercise for AS,[5] there is neither any supporting evidence in the literature nor any studies in which swimming exercises are given. Furthermore, though the number of studies in which walking exercise was given as part of aerobic exercise is limited,[28, 29] it is noteworthy that increase in functional capacity was more pronounced in groups that performed aerobic exercises than the control group. Both swimming and walking can be recommended to AS patients after general (*e.g.*, determination of any problems that might hinder walking) and social status of the patient (*e.g.*, having access to swimming facilities) are established.

Review of the literature showed that subjective measures (BASFI) are used generally to assess the functional capacity in AS patients.[30-32] In the present study, BASFI scores did not show significant changes with exercise in any of the three exercise groups. BASFI scores of our patients were found to be lower than the patient scores in other studies.[3, 33] Therefore, a major improvement was not noted. Some researchers have reported the positive effect of exercise programs on functional state, whereas others have not detected any difference between home-based exercises and the control group.[32-34] What makes the present study different from the previous studies is that we used objective measures (p$\dot{V}O_2$, 6MWT) as well as BASFI to evaluate the functional capacity. Though there was no increase in BASFI in our study, objective tests revealed increases in our study.

In our study, joint mobility was assessed by BASMI, hand-to-floor distance and chest expansion and, at the end of the study, an increase was observed only in chest expansion only in the swimming group.

Increase in chest expansion has been reported in numerous studies although the duration of the disease was shorter than the present study (<15 years) or the length of exercise period was longer (up to one year).[11, 14] This may explain why there were no changes in BASMI and hand-to-floor distance. An hypothesis as to why this change was observed only in the swimming group was not suggested. According to the authors, the features of exercises effective on joint mobility need to be established with future studies. In that respect, the present study would be a guide for future studies.

BASDAI represents major symptoms experienced by patients with AS.[35] In the present study, BASDAI scores have revealed improvement in swimming exercise group. Although Sweeney *et al.* noted in their study [30] that there is no difference between exercise and control groups in terms of BASDAI, Karatepe *et al*,'s study reported a significant improvement.[12] Fernández-de-Las-Peñas *et al.*, supporting present research results, did not observe a significant difference in stiffness between supervised and unsupervised exercise groups.[32] On the other hand, Altan *et al.* found that improvement in BASDAI was greater in the balneotherapy and CE group than in the CE-only group. The baseline BASDAI scores were low in all three exercise groups and the decrease in symptoms in the swimming exercise group was more prominent than in the CE group.[36]

General life quality assessment scales have not been widely used in studies related to AS.[37] Yet, it is evident that there should be an improvement in these patients' quality of life in order to talk about the success of treatment. Altan *et al.* observed improvements in many of the scores of the NHP after a three-week balneotherapy and CE in comparison to the CE-only group.[36] Lim *et al.*[38] found an increase in the quality of life in the exercise but not in the control group. We observed increases in energy level, emotional reaction and physical mobility subscores of the NHP in all three exercise groups. Improvements in all exercise groups were attributed to satisfaction due to attention paid to the patients by the researchers, regular follow-up of the patients and subjective well-being of the patients as a result of exercise. Further, AS patients who participated in the exercise program expressed happiness during subjective assessment of the study. This state of happiness was more pronounced in swimming exercise group.

To date, most studies of AS have focused on physical health and outcomes rather than the impact of the disease on psychological health.[28, 29] It has been emphasized that increased disease activity and functional disability are related to poor mental health.[39, 40] BDI scores were low at the beginning of the study in all groups and there were no significant changes at the end of the study. The reason behind the higher BDI scores in some studies compared to the scores of the patients in our study may be the possibility not to change after treatment in BDI.[2, 4] Consequently, as psychological symptoms of patients with AS also effect the quality of life, this factor should be taken into consideration in the evaluation of patients and should be included in the assessment stages of the treatment success.

This, to the best of authors' knowledge, is the first study that compared swimming, walking and CE in patients with AS. Even though the efficiency of swimming in AS patients has been reported and swimming is recommended in clinical practice, no studies that investigated swimming exercises in these patients exist in the literature. There are also no exercise studies in the literature that assessed functional capacity objectively by $p\dot{V}O_2$ measurements. Among the constraints of the present study were short duration of rehabilitation, male dominance among patients, not investigating the long-term effects of exercises and not investigating the effects of exercises on early- and late-stage AS patients.

Conclusions

In conclusion, swimming, walking and CE had beneficial effects on quality of life and pulmonary functions. Aerobic exercises such as swimming and walking in addition to CE caused an increase in functional capacity of patients. The importance of exercise on functional capacity and quality of life in patients diagnosed with AS is well-established. However, which type of exercise is more effective is yet to be determined. This study would serve as a guide for future studies on this matter. Due to the fact that swimming improved the symptoms and chest mobility better than the CE, this study would shed light to future studies with swimming exercise of longer duration.

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