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RESEARCH ARTICLE

One-Year Follow-up of Two Exercise Interventions for the Management of Patients with Ankylosing Spondylitis

A Randomized Controlled Trial

ABSTRACT

Fernández-de-las-Peñas C, Alonso-Blanco C, Alguacil-Diego IM, Miangolarra-Page JC: One-year follow-up of two exercise interventions for the management of patients with ankylosing spondylitis: A randomized controlled trial. Am J Phys Med Rehabil 2006;85:559–567.

Objective: To assess the long-term effects on functional and mobility outcomes of two exercise interventions for the management of patients with ankylosing spondylitis.

Design: In an extended 12-mo follow-up of a randomized controlled trial, 40 patients who were diagnosed with ankylosing spondylitis according to the modified criteria of New York, allocated to control or experimental groups using a random numbers table, and who performed their respective exercise program at least three times per month, were included in this long-term study. The control group was treated during 15 sessions with a conventional exercise regimen in ankylosing spondylitis, whereas the experimental group received 15 sessions of exercises based on the treatment of the shortened muscle chains following the guidelines described by the Global Posture Reeducation method. These patients were followed up and assessed again 1 yr after entering the study, reapplying the same validated indexes: BASMI (Bath Ankylosing Spondylitis Metrology Index [tragus to wall distance, modified Schober test, cervical rotation, lumbar side flexion, and intermalleolar distance]), BASDAI (Bath Ankylosing Spondylitis Disease Activity Index), and BASFI (Bath Ankylosing Spondylitis Functional Index).

Results: The intragroup comparison between follow-up and postintervention data showed that both groups decrease their clinical and functional measures during the follow-up period. This decrease was only significant for lumbar side flexion and intermalleolar distance measurements, being more significant in the control group ($P = 0.001$ and $P = 0.002$, respectively). Intragroup differences between follow-up and preintervention assessments revealed that improvements in all mobility measures of the BASMI index and in the BASFI index were partially maintained at the 12-mo follow-up in the experimental group but not in the control group. The intergroup comparison (unpaired *t* test analysis) between changes on each outcome during the long-term follow-up (post–follow-up; and pre–follow-up) showed no significant differences in the decrease between postintervention and follow-up data between the study groups. On the other hand, the intergroup comparison between preintervention and follow-up data revealed significant differences in almost all mobility measures of the BASMI index (except for cervical rotation) and in the BASFI index, in favor of the experimental group.

Conclusions: An exercise regimen based on the Global Posture Reeducation method and focusing on specific strengthening and flexibility exercises of the shortened muscle chains offers promising short- and long-term results in the management of patients who have ankylosing spondylitis.

Key Words: Ankylosing Spondylitis, Physical Therapy, Functional Index, Activity Index, Metrology Index

Ankylosing spondylitis (AS) is a chronic rheumatic disorder involving the axial skeleton that progressively limits spinal mobility.[1] According to previous series, the prevalence of AS is 0.1–1.4%.[2,3] The male-to-female ratio is about 2:1 to 3:1.[4] Based on available data, AS patients have about a 50% increased risk of mortality.[5] Evidence suggests that the progression is stronger in the first 10 yrs of the disease, but it is also clear that the disease keeps on being active for further decades. Early limitation of spinal mobility has been identified as one of the most important prognostic factors.[5]

There is no definitive treatment for AS, but good control of the disease can be achieved. Exercises are considered as basic therapy to increase the functional capacity and quality of life in these patients. The Cochrane Musculoskeletal Group found that supervised physiotherapeutic exercises were better than home exercises in improving pain, stiffness, movement in the spine, and overall well-being.[6] Otherwise, the Cochrane Musculoskeletal Group did not find any randomized trial investigating different physical therapy protocols in patients with AS.[6] Accordingly, we still do not know which particular exercise regimen to use when we meet a patient who has AS.[6]

Although there are different exercises for AS, not all of these regimens are specific for patients with this disease. Moreover, the Cochrane Musculoskeletal Group, based on the variety of results from the different analyzed studies in their review, suggested that exercise programs should be specific for patients with AS.[6] Fernández-de-las-Peñas et al.[7] recently demonstrated that AS patients treated with an exercise regimen based on the Global Posture Reeducation Method (GPR)[8] and focused on specific strengthening and flexibility exercises of the affected muscle chains in AS (Figs. 1 and 2),[8,9] showed a greater improvement in functional and mobility outcomes than those patients who received a conventional regimen of analytic exercises. To our knowledge, our short-term study has been the first study in the peer-reviewed literature analyzing different specific physical therapy regimens in patients with AS.[6]

Because AS is a chronic disease, it is imperative to assess long-term effects of the interventions applied to these patients. Several studies have analyzed the therapeutic effects of different analytic exercise programs at long-term follow-up periods.[10,11] Therefore, to evaluate whether the improvement achieved with the analyzed exercise regimens in our short-term study[7] can be maintained after the conclusion of the intervention, we carried out a follow-up study.

The present study assessed the follow-up efficacy of both exercise programs 12 mos after the conclusion of the intervention. We hypothesized that patients allocated to the GPR exercise protocol would maintain a greater proportion of their clinical improvement than those receiving conventional exercises.

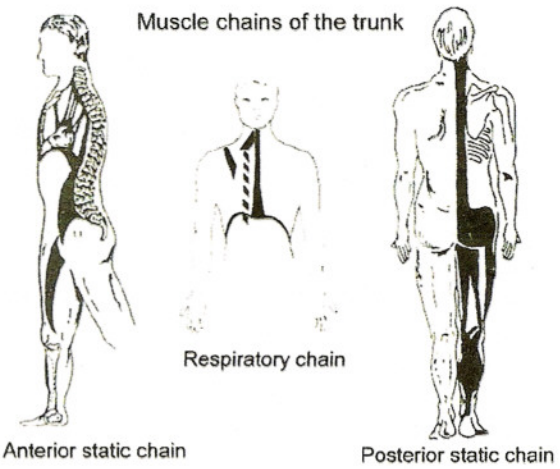

FIGURE 1 *Muscle chains of the trunk according to the global posture reeducation method.*

MATERIALS AND METHODS

Study Protocol

A randomized controlled trial evaluating the effect of a 4-mo comprehensive protocol of strengthening and flexibility exercises based on the GPR method *vs.* conventional analytic exercises for AS patients on functional and mobility outcomes was conducted in the Department of Physical Therapy, Occupational Therapy, Rehabilitation and Physical Medicine of the Universidad Rey Juan Carlos, Alcorcón, Spain, during 2002–2003. A total of 40 patients diagnosed with AS by their rheumatologist according to the modified criteria of New York[12] and giving their informed consent were randomly allocated to control or experimental groups using a random numbers table. Changes in activity, mobility, and functional capacity were taken initially (pre) and at the end of the 4-mo treatment period (post) using the following validated indexes: the Bath Ankylosing Spondylitis Metrology Index (BASMI),[13] the Bath Ankylosing Spondylitis Functional Index (BASFI),[14] and the Bath Ankylosing Spondylitis Disease Activity Index (BASDAI).[15] Detailed methods of this trial were published[7] and are only summarized in this extended follow-up article. The same validated indexes were used again as an extended follow-up assessment performed 12 mos after the conclusion of the 4-mo intervention period.

Inclusion and exclusion criteria for this extended follow-up study were the same as for the short-term study.[7] Exclusion criteria included a

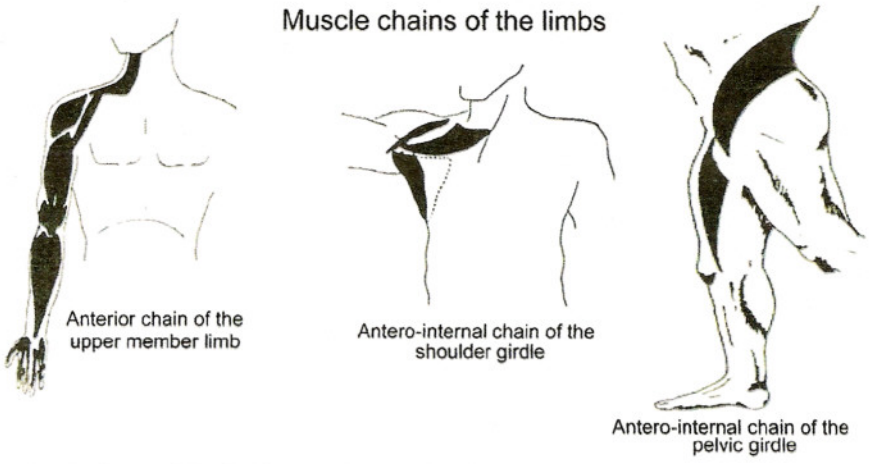

FIGURE 2 *Muscle chains of the limbs according to the global posture reeducation method.*

medical condition that impaired function more than AS, osteoporosis, or a history of fractures secondary to osteoporosis. One additional criterion of this long-term study was that only those AS patients who received exclusively their randomly allocated intervention regimen during the treatment period were included.

At the end of the 4-mo intervention period and during the follow-up, patients were encouraged to continue their respective exercise regimen once a week. A second additional criterion of this long-term study was that only patients who performed their respective exercise program at least three times per month were included. During the follow-up period, patients were asked about their life habits. Ninety percent of the patients had been practicing swimming-pool exercises for 2 yrs before beginning the study, so this circumstance was controlled during the follow-up period. All patients were taking different types of nonsteroidal anti-inflammatory drugs, and the rheumatologist ensured that the pharmacological treatment of each patient was stable during the follow-up period.

Physical Therapy Interventions

For 4 mos, patients participated in a weekly group session ($n = 15$ sessions) of 1 hr in duration that was supervised by an experienced physical therapist. The control group received a conventional physical therapy intervention, which consisted of 20 exercises[16,17] (Appendix 1). This protocol included analytic flexibility exercises of the cervical, thoracic, and lumbar spine. The intervention also included stretching of the erector spine muscle, hamstring muscles, and shoulder muscles. At the end of each session, chest expansion exercises and control abdominal and diaphragm breathing exercises were performed. This protocol was supervised by physiotherapist 1.

The experimental group received a different physical therapy intervention based on the treatment of the shortened muscle chains following the guidelines described by the GPR method.[8] This method employs specific strengthening and flexibility exercises in which the shortened muscle chains (Figs. 1 and 2) are stretched. Examples of different exercises of this method can be found in our previous short-term study.[7] This protocol was supervised by a second physical therapist. Appendix 2 summarizes the experimental intervention.

During the follow-up period, patients performed their respective exercise programs in the same intervention group without any supervision. Once a month, the exercise regimen was supervised by the respective physical therapist who participated in the short-term study to assess that the program was going correctly.

Outcome Measures

The extended follow-up assessment comprised the identical validated indexes as used at the initial visit and at the end of the 4-mo treatment period. The BASMI[13] index includes five physical measures: tragus to wall distance, modified Schober test, cervical rotation, lumbar side flexion, and intermalleolar distance. A cervical goniometric device manufactured by Performance Attainment Associates (St. Paul, MN) was employed for active cervical rotation assessment. Both sides were measured, and the mean of the obtained values was calculated. Patients repeated all movements three times, and the mean of these values was employed in the posterior analysis. The BASFI[14] index analyzes the functional capacity of the patient with AS to perform the daily activities. A higher score on the BASFI reflects greater limitation. The BASDAI[15] index consists of six questions related to five symptoms during the last week: fatigue, spinal pain, joint pain, tenderness, and morning stiffness. A

higher score on the BASDAI reflects greater disease activity. Readers might usefully explore psychometric properties of these indexes elsewhere.[18]

Follow-up data were assessed by the same external assessor as in our short-term study[7] who was blinded to the intervention group. Outcome measures were assessed without any previous warming up and before any kind of exercise.

Statistical Analysis

Data were introduced in the SPSS package, version 12.0 (SPSS, Chicago, IL). Mean values, standard deviation, or 95% confidence intervals of the variables were calculated. The Kolmogorov-Smirnov test showed a normal distribution of the quantitative outcomes ($P > 0.05$). A one-way analysis of variance for repeated measures was used to compare the intragroup scores of each variable during the study (the Bonferroni correction was used for post hoc analysis). The intergroup data between the groups at the beginning of the trial (pretreatment) were assessed with the unpaired t test. The intergroup comparison between changes at different assessments (post–follow-up, pre–follow-up scores) in both study groups was analyzed with the unpaired t test. Statistical analysis was conducted at a 95% confidence level. A P value of <0.05 was considered as statistically significant.

RESULTS

The same initial patients of the short-term study were included in the follow-up analysis. Eighty percent of the patients ($n = 32$) performed their exercise regimen for all weeks, whereas the remaining 20% ($n = 8$) performed their respective exercise group regimen ≥3 wks/mo (mean, 3.25 times per month). Therefore, 15 men and five women, aged 25–62 yrs old (mean age, 45 ± 9 yrs), comprised the experimental group, whereas 16 men and four women, aged 29–58 yrs old (mean age, 46 ± 8 yrs), formed the control group. Length of the disease was similar in both study groups (7.6 yrs in the control group, 8 yrs in the experimental group). No significant differences for gender ($P = 0.6$), age ($P = 0.6$), length of the disease ($P = 0.2$), or American College of Rheumatology (ACR) classification ($P = 0.1$) were found between the groups.[7] As we reported previously,[7] no statistically significant differences in any outcome of the BASMI index, or in either BASFI or BASDAI indexes, were found between the groups at the beginning of the short-term study. It could therefore be assumed that they were comparable in all respects at the start of the study (pretreatment data). Clinical measures of the BASMI index and total scores of the BASFI and BASDAI indexes at the beginning of the study are summarized in Table 1 for the experimental group and in Table 2 for the control group.

Table 1 details data of the preintervention, postintervention, and follow-up status of the experimental group, whereas Table 2 summarizes the same findings in the control group. The intragroup comparison between follow-up and postintervention assessments showed that both groups decrease their clinical and functional measures during the 12-mo follow-up period. This decrease in the experimental group was significant for lumbar side flexion and intermalleolar distance measurements ($P = 0.01$). The control group also showed a decrease in the same outcomes (i.e., lumbar side flexion and intermalleolar distance being more significant, $P = 0.001$ and $P = 0.002$, respectively). Table 3 details the intragroup differences (pre–post, post–follow-up, and pre–follow-up) in functional and clinical outcomes in both study groups.

The intragroup differences between follow-up and preintervention assessments revealed that improvements in all mobility measures of the BASMI index and in the BASFI index were partially maintained at the 12-mo follow-up period in the experimental group (Table 3). On the other hand, the control group did not maintain the improvement obtained during the 4-mo treatment period at the 12-mo follow-up period (Table 3).

TABLE 1 Mean (SD) of preintervention, postintervention, and follow-up data of the experimental group

	Preintervention	Postintervention	Follow-up
Tragus-to-wall distance, cm	7 (4.1)	5.1 (3.9)	5.2 (3.4)
Modified Schober test, cm	1.8 (1.3)	2.4 (1.1)	2.4 (1)
Cervical rotation, degrees	46 (21)	57 (18)	52 (14)
Lumbar side flexion, cm	3.9 (2.5)	6.3 (2.5)	5.4 (2.4)
Intermalleolar distance, cm	81.7 (11.2)	90.8 (11.2)	86.8 (10)
BASFI total score	51.8 (20.8)	45.7 (20.6)	46.7 (19.9)
BASDAI total score	27.6 (9.1)	26 (11.3)	26.8 (10.7)

BASFI, Bath Ankylosing Spondylitis Functional Index; BASDAI, Bath Ankylosing Spondylitis Disease Activity Index.

Finally, the intergroup comparison (unpaired *t* test analysis) between changes on each outcome during the long-term study (post–follow-up and pre–follow-up) showed no significant differences in the decrease between postintervention and follow-up data between the study groups. On the other hand, the comparison between preintervention and follow-up data revealed significant differences in almost all mobility measures of the BASMI index (except for cervical rotation) and in the BASFI index in favor of the experimental group. Table 4 summarizes the intergroup comparison of these changes between the groups.

DISCUSSION

Previous studies have demonstrated that physiotherapeutic exercise improves spinal mobility and also reduces functional impairment in patients with AS.[9,16,19] Nevertheless, the interventions were often poorly described, and the exact content of the exercise programs remained partly unclear.[6] To our knowledge, this is the first long-term study analyzing different physical therapy exercise programs in AS.[6,7]

Our short-term study showed that the improvement obtained with the exercise regimen based on the GPR method was greater than the improvement obtained with a conventional physical therapy program.[7] The present long-term study has demonstrated that AS patients who received the GPR exercise program get better short-term results than the control group[7]and maintained a greater proportion of their clinical improvement than those patients receiving a conventional physical therapy program based on analytic stretching and mobilizing exercises. Based on the present

TABLE 2 Mean and standard deviation of preintervention, postintervention, and follow-up data of the control group

	Preintervention	Postintervention	Follow-up
Tragus to wall distance, cm	6.2 (5.2)	4.3 (4.1)	5.4 (3)
Modified Schober test, cm	2.5 (1.3)	2.7 (1.3)	2.6 (1.3)
Cervical rotation, degrees	54 (15)	57 (9)	55 (10)
Lumbar side flexion, cm	4.8 (2.3)	6.2 (2.6)	5.4 (2.4)
Intermalleolar distance, cm	86.1 (8.2)	88.5 (8.2)	84.8 (7.2)
BASFI total score	47 (19)	46.5 (21)	48 (19.4)
BASDAI total score	28.5 (10)	26.2 (8.6)	28 (8.9)

BASFI, Bath Ankylosing Spondylitis Functional Index; BASDAI, Bath Ankylosing Spondylitis Disease Activity Index.

TABLE 3 Intragroup differences during the long-term study in functional and clinical outcomes after intervention by group

	Pre–Post Data	Post–Follow-up Data	Pre–Follow-up Data
Experimental group			
Tragus to wall distance, cm	1.9 (2.1), $P = 0.001$	−0.1 (1), P = NS	1.8 (1.5), $P < 0.001$
Modified Schober test, cm	0.6 (0.6), $P = 0.001$	0 (0.4), P = NS	0.6 (0.6), $P = 0.002$
Cervical rotation, degrees	11 (15), $P = 0.005$	−5 (6), P = NS	7 (15), $P = 0.04$
Lumbar side flexion, cm	2.4 (1.4), $P = 0.001$	−1 (1.2), $P = 0.01$	1.4 (0.5), $P < 0.01$
Intermalleolar distance, cm	9.1 (8), $P = 0.002$	−4 (3.6), $P = 0.01$	5 (5.1), $P = 0.001$
BASFI total score	−6.1 (8), $P = 0.003$	1 (2.7), P = NS	−5.1 (6.3), $P = 0.006$
BASDAI total score	−1.6 (5.7), P = NS	0.8 (2.1), P = NS	−0.8 (4), P = NS
Control group			
Tragus to wall distance, cm	1.9 (1.8), $P = 0.009$	−1.1 (2.6), P = NS	0.8 (3.9), P = NS
Modified Schober test, cm	0.2 (0.5), P = NS	−0.1 (0.2), P = NS	0.1 (0.6), P = NS
Cervical rotation, degrees	3 (10), P = NS	−2 (3), P = NS	1 (7), P = NS
Lumbar side flexion, cm	1.4 (1.3), $P = 0.02$	−0.8 (0.6), $P = 0.001$	0.6 (0.8), $P = 0.01$
Intermalleolar distance, cm	2.4 (8.4), P = NS	−3.8 (4.2), $P = 0.002$	−1.4 (5.3), P = NS
BASFI total score	−0.5 (8.7), P = NS	1.5 (3.1), P = NS	−1 (7.4), P = NS
BASDAI total score	−2.3 (5.8), P = NS	1.7 (3.5), P = NS	−0.5 (3.3), P = NS

NS, nonsignificant (P values came from the analysis of variance test; the Bonferroni correction was used as post hoc analysis); BASFI, Bath Ankylosing Spondylitis Functional Index; BASDAI, Bath Ankylosing Spondylitis Disease Activity Index. Values are expressed as mean (standard deviation).

In general, positive values express an increase and negative values reflect a decrease in the clinical measure, except for total scores in BASFI and BASDAI indexes, in which positive values express a decrease and negative values express an increase.

TABLE 4 Intergroup comparison of changes (post–follow-up and pre–follow-up) during the study between the groups

	Post–Follow-up Scores Control Group	Post–Follow-up Scores Experimental Group	F (*P* score of Levene)	*P*
Tragus to wall distance, cm	−1.1 (95% CI: −2.6,−0.4)	−0.1 (95% CI: −0.6,0.4)	16.2 (0.001)	NS
Modified Schober test, cm	−0.1 (95% CI: −0.2,0.1)	0 (95% CI: −0.2,0.2)	1.1 (0.3)	NS
Cervical rotation,degrees	−2 (95% CI: −4,0)	−5 (95% CI: −6,0)	5.9 (0.02)	NS
Lumbar side flexion, cm	−0.8 (95% CI: −1.2,−0.4)	−1 (95% CI: −1.8,−0.3)	5.3 (0.02)	NS
Intermalleolar distance, cm	−3.8 (95% CI: −4.5,1)	−4 (95% CI: −6.1,−2)	0.08 (0.8)	NS
BASFI total score	1.5 (95% CI: 0,3.3)	1 (95% CI: 0.6,2.5)	0.007 (0.9)	NS
BASDAI total score	1.7 (95% CI: 0,3.8)	0.8 (95% CI: 0.5,1.2)	9.2 (0.004)	0.04
	Pre–Follow-up Scores Control Group	Pre–Follow-up Scores Experimental Group	F (*P* score of Levene)	*P*
Tragus to wall distance, cm	0.8 (95% CI: −1.5,3)	1.8 (95% CI: 1,3)	12.6 (0.001)	NS
Modified Schober test, cm	0.1 (95% CI: −0.5,0.2)	0.6 (95% CI: −0.2,1)	0.7 (0.3)	0.03
Cervical rotation, degrees	1 (95% CI: −5.3,3.3)	7 (95% CI: 3,16)	9.9 (0.003)	NS
Lumbar side flexion, cm	0.6 (95% CI: −1,1)	1.4 (95% CI: 1.1,1.7)	4.1 (0.05)	0.001
Intermalleolar distance, cm	−1.4 (95% CI: −4.5,1.7)	5 (95% CI: 2,8)	0.08 (0.9)	0.001
BASFI total score	−1 (95% CI: −5.3,3.3)	−5.1 (95% CI: −1.3,−8.8)	0.2 (0.6)	0.008
BASDAI total score	−0.5 (95% CI: −1.4,2.5)	−0.8 (95% CI: −1.4,1.2)	5.1 (0.03)	NS

F, Levene test to assess the homogeneity of the variance; NS, nonsignificant; BASFI, Bath Ankylosing Spondylitis Functional Index; BASDAI, Bath Ankylosing Spondylitis Disease Activity Index.

Values are expressed as mean (95% confidence interval); *P* values come from independent (unpaired) samples Student's *t* test analysis.

In general, positive values express an increase and negative values reflect a decrease in the clinical measure, except for total scores in BASFI and BASDAI indexes, in which positive values express a decrease and negative values an increase.

results, it seems that exercise programs should be continued by the patients with the aim to maintain their mobility. However, the question that clinicians need to answer is: which exercise program provokes the best results for our patients? Our short-term study[7] and the present extended follow-up study suggest that a global and functional approach is more effective than analytic exercises in AS patients.

Based on previous[7] and current findings, it seems that the treatment of the shortened muscle chains (Figs. 1 and 2), according to the GPR method,[8] can be more beneficial than conventional analytic exercise regimens in patients with AS. According to the GPR method, muscle chains are constituted by gravitational muscles (i.e., erector spine muscles, piriformis muscle, scalene muscles, suboccipital muscles), which work in a synergistic function depending on the muscle chain (e.g., the muscular function of the posterior static chain of the body is to permit the standing position against gravity).[8] The analytic stretching of any of these muscles could be expanded to include secondary adaptive changes in the rest of the muscle chain, so the analytic stretching of any individual gravitational muscle would be inefficient if it is not associated with a stretching of the whole muscle chain.[8] Therefore, the GPR method employs specific flexibility exercises in which these shortened muscle chains are stretched.[7,8] Although promising data might derive from our study, further research is required to elucidate the role of these functional muscle chains in AS patients.

There is some evidence suggesting that spinal mobility obtains a greater improvement with a group physical therapy program than with home exercises.[6] Mutual encouragement, reciprocal motivation, and exchange of experience as some advantages of group physical therapy intervention might be some of the contributing factors to these findings.[6] Therefore, future studies evaluating the therapeutic effects of different physical therapy exercise regimens should be performed in groups supervised by experienced physical therapists.

In the present study, changes in activity, mobility, and functional capacity were evaluated using previously validated indexes.[13–15] Although the BASMI index has very good qualities,[13] Heikkila et al.[20] reported that several measures are not sensitive and that others are. Based on their analysis, the BASMI index has one measure in the top level (lumbar side flexion), two at the middle level (cervical rotation and intermalleolar distance), and two not suggested (Schober test and tragus to wall distance). The reason to use the BASMI index was that it is the only validated index (criterion validity and interobserver reliability determined) in the peer-reviewed literature that assesses the status of the axial skeleton in pa-

tients with AS. The BASFI index was shown to be sensitive to demonstrating an improvement in the functional ability in AS patients[14] and has more items displaying differential item functioning than the Dougados Functional Index.[21] Finally, the BASDAI index represents major symptoms experienced by patients with AS and has demonstrated very good qualities.[15] In our study, changes in the BASDAI index after both interventions were not statistically significant. This situation could be caused by the small simple size. Probably, a greater number of patients might show statistically significant differences.

Our study has several limitations. The first one was the small sample size. Type II errors could have happened, so it is recommended to repeat the same procedure with a greater number of patients. Another limitation could be the influence of some clinical features such as age, sex, length of the disease, and other circumstances of the analyzed patients; however, demographic and clinical data from our AS patients were similar to those reported in previous studies. Finally, we did not analyze the effects of the pharmacological treatment, which we know helped patients during the study. All patients received nonsteroidal anti-inflammatory drug treatment for ≥10 yrs (controlled by their rheumatologist); however, during the study, it was emphasized to all patients not to modify their pharmacological treatment. On the other hand, something we thought could positively affect the results was the swimming pool exercise. The whole sample size (90%) had already been doing swimming pool exercise for several years, and it was included in their habitual practice. Therefore, it was not modified because the swimming pool program was the same for all patients, so we considered that the obtained improvement would affect both groups in the same way.

CONCLUSION

AS patients who received an exercise program based on the GPR method, besides getting better short-term results, maintained a greater proportion of their clinical improvement than those patients receiving a conventional physical therapy exercise program based on analytic stretching and mobilizing exercises. The exercise regimen based on the GPR and focusing on specific strengthening and flexibility exercises of the shortened muscle chains offers promising short- and long-term results in the management of patients with AS.

APPENDIX 1 Conventional physical therapy intervention

Number	Position of the Patient	Exercise	Repetitions
1	Seated	Cervical lateral flexion	2 series of 10 repetitions each
2	Seated	Cervical rotation	2 series of 10 repetitions each
3	Seated	Cervical flexion-extension	2 series of 10 repetitions each
4	Seated	Thoracic rotation	2 series of 10 repetitions each
5	Standing	Thoracic lateral-flexion	2 series of 10 repetitions each
6	Standing	Thoracic flexion-extension	2 series of 10 repetitions each
7	Standing	Thoracic muscles stretching	2 repetitions of 45 second each
8	Standing	Hamstring muscles stretching	2 repetitions of 45 second each
9	Standing	Gastrocnemius muscle stretching	2 repetitions of 45 second each
10	Standing	Strengthening of quadriceps muscle	2 series of 8 repetitions each
11	Kneeling	Psoas muscle stretching	2 repetitions of 45 second each
12	Lying supine	Posterior pelvic girdle gliding	2 series of 8 repetitions each
13	Lying supine	Active flexion of the upper cervical spine	2 series of 8 repetitions each
14	Lying supine	Superior abdominal strengthening	2 series of 10 repetitions each
15	Lying supine	Inferior abdominal strengthening	2 series of 10 repetitions each
16	Lying supine	Lumbar spine rotation	2 series of 8 repetitions each
17	Lying on the side	Coxofemoral abduction	2 series of 10 repetitions each
18	Lying on the side	Shoulder abduction	2 series of 10 repetitions each
19	Kneeling–hand position	Anteroposterior pelvic girdle gliding	2 series of 10 repetitions each
20	Kneeling–hand position	Anteroposterior lumbar and thoracic gliding	2 series of 10 repetitions each

APPENDIX 2. Experimental physical therapy intervention: Scheme of the experimental intervention (divided in six phases) and the exercises to stretch the specific muscle chains[a]

Phase	Purpose of Each Phase	Exercises	Repetitions
1. General warming-up	All exercises in this phase will be performed standing and/or walking	1. Stretching exercise of the posterior muscle chain. 2. Stretching exercise of the anterior muscle chain. 3. Neural mobilization of the median nerve.[b]	2 series of 8 repetitions each
2. Specific warming-up	Exercises in this phase are focussed on improving the pelvic girdle mobility	1. Anteroposterior pelvic girdle gliding. 2. Extension–flexion motion of the lumbar spine (McKenzie method). 3. Stretching exercise of the anterior muscle chain in the pelvic region. 4. Stretching exercise of the posterior muscle chain in the pelvic region.	2 series of 8 repetitions each
3. Dynamic axial exercise	Exercises in this phase will be performed lying supine and prone	1. Prone exercises. Anterior pelvic girdle gliding. 2. Anteroposterior pelvic girdle gliding in supine. 3. Rotation stretching of the posterior muscle chain.	2 series of 10 repetitions each
4. Static postural exercise	Exercises in this phase are focused on stretching and strengthening the shortened muscle chains	1. Stretching exercise of the anterior muscle chain in supine. 2. Stretching exercise of the posterior muscle chain seated. 3. Stretching exercise of the posterior muscle chain seated on the wall. 4. Stretching exercise of the anterior muscle chain standing. 5. Eccentric work of the erector spine muscles.	All stretching postures have to be maintained during 3–4 mins each
5. Specific respiratory exercises	All respiratory exercises will be performed in a stretching posture during phase 4	1. Thoracic breathless. 2. Expiratory breathless. 3. Stretching of the anterointernal muscle chain of the scapular girdle.	2 series of 10 repetitions each
6. Cooling down	This phase will consist of slightly neck and thoracic exercises. All exercises will be performed walking	1. Cervical flexion-extension.	1 series of 5 repetitions each

[a] More details about these exercises may be found elsewhere.[2,13] Pictures of some exercises can be found in our short-term study.[7]

[b] Kleinrensink GJ, Stoeckart R, Mulder PG, et al: Upper limb tension tests as tools in the diagnosis of nerve and plexus lesions: Anatomical and biomechanical aspects. Clin Biomech 2000;15:9–14.

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