Authors:

César Fernández-de-las-Peñas, PT
Cristina Alonso-Blanco, PT
Matilde Morales-Cabezas, MD
Juan Carlos Miangolarra-Page, MD, PhD

Affiliations:

From the Research and Teach Unit of Physical Therapy, Occupational Therapy, Physical Medicine and Rehabilitation, Universidad Rey Juan Carlos, Madrid, Spain.

Correspondence:

All correspondence and requests for reprints should be addressed to César Fernández de las Peñas, Facultad de Ciencias de la Salud, Universidad Rey Juan Carlos, Avenida de Atenas s/n, 28922 Alcorcón, Madrid, Spain

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RESEARCH ARTICLE

Two Exercise Interventions for the Management of Patients with Ankylosing Spondylitis

A Randomized Controlled Trial

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Objective: The purpose of this clinical trial was to evaluate the impact of a 4-month comprehensive protocol of strengthening and flexibility exercises developed by our research group versus conventional exercises for patients with Ankylosing Spondylitis (AS) on functional and mobility outcomes.

Design: Randomized controlled trial. Forty-five patients diagnosed with AS according to the modified criteria of New York were allocated to control or experimental groups using a random numbers table. The control group was treated with a conventional protocol of physical therapy in AS, whereas the experimental group was treated with the protocol suggested by our research group. The conventional intervention consisted of 20 exercises: motion and flexibility exercises of the cervical, thoracic, and lumbar spine; stretching of the shortened muscles; and chest expansion exercises. The experimental protocol is based on the postural affectation of the AS and the treatment of the shortened muscle chains in these patients according to the Global Posture Reeducation (GPR) method. This intervention employs specific strengthening and flexibility exercises in which the shortened muscle chains are stretched and strengthened. The study lasted 4 mos. During this period, patients received a weekly group session managed by an experienced physiotherapist. Each session lasted an hour, and there were 15 total sessions. Changes in activity, mobility, and functional capacity were evaluated by an assessor blinded to the intervention, using the following previously validated scores from the Bath group: BASMI (tragus to wall distance, modified Schöber test, cervical rotation, lumbar side flexion, and intermalleolar distance), BASDAI (The Bath Ankylosing Spondylitis Disease Activity Index), and BASFI (The Bath Ankylosing Spondylitis Functional Index).

Results: Both groups showed an improvement (prepost scores) in all the outcome measures, mobility measures of the BASMI index, as well as in BASFI and BASDAI indexes. In the control group, the improvement in tragus to wall distance ($P = 0.009$) and in lumbar side flexion ($P = 0.02$) was statistically significant. Although the rest of the outcomes also improved, they did not reach a significant level ($P > 0.05$). In the experimental group, the improvement in all the clinical measures of the BASMI index ($P < 0.01$) and in the BASFI index ($P = 0.003$) was statistically significant. The intergroup comparison between the improvement (prepost scores) in both groups showed that the experimental group obtained a greater improvement than the control group in all the clinical measures of the BASMI index, except in tragus to wall distance, as well as in the BASFI index.

Conclusions: The experimental protocol developed by our research group, based on the GPR method and specific strengthening and flexibility exercises of the muscle chains, offers promising results in the management of patients suffering from AS. Further trials on this topic are required.

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

Ankylosing Spondylitis (AS) is a chronic rheumatic disorder affecting mainly the axial skeleton, which progressively limits spinal and thoracic mobility throughout the course of the disease.[1] Pain and structural lesions within the evolutionary frame of the disease force the patient to adopt antialgical postures, leading to the typical distortions frequently observed in these patients: protrusion of the jaw, thoracic kyphosis, loss of lumbar curve, protraction of the scapular girdle, and flexion and internal rotation of the pelvic girdle.[2] According to published series the prevalence of AS is 0.1% to 1.4%.[3,4] The male to female ratio is about 2:1 to 3:1.[5] Based on available data, AS patients have about a 50% increased risk of mortality.[6] There is some evidence 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.[6]

There is no definitive treatment of AS, but good control of the disease can be achieved. Physical therapy is highly recommended. The aim of the physiotherapy treatment in AS is to maintain or improve general functioning and quality of life. The long-term goal for the patient is to try to maintain a good posture, with the primary aim being to avoid stiffening in a flexed position.[7] Previous trials have analyzed the therapeutic effects of three modalities of physical therapy interventions: supervised individualized therapy,[8] group therapy supervised by a physical therapist,[9] and homework performed by the own patient.[10] All these studies have demonstrated that physiotherapeutic exercise improves spinal mobility and also reduces functional impairment in these patients. Ramos et al reported that the best results in improving mobility and reducing functional impairment were obtained with group therapy, while individual therapy at home attained the worst results.[11] This conclusion has been confirmed by the review of the Cochrane Musculoskeletal Group, which reported that supervised physiotherapeutic exercises in group have a greater short term beneficial effects than home exercise programs.[12] Otherwise, the Cochrane Musculoskeletal Group has not found any randomized trial investigating different physical therapy protocols in patients with AS.[12] Accordingly, we still do not know which particular treatment protocol to use when we meet a patient suffering from AS.[12]

There are different exercises for AS. Conventional protocols of physical therapy consist of analytic flexibility exercises of the cervical, thoracic and lumbar spine, and analytic stretching of the erector spine muscles, hamstring muscles, and shoulder muscles. However, not all of these exercises are specific for patients with this disease. In France, Italy, and Spain there is a physical therapy method called "Global Posture Reeducation" (GPR), which was developed by Phillipe Souchard[13] based on 20 yrs of clinical experience. This method deals with the existence of different muscle chains: the posterior static chain of the body (Fig. 1), the anterior diaphragmatic chain (Fig. 2), and the anterointernal chain of the pelvic (Fig. 3) and scapular girdles (Fig. 4).[13] All these muscle chains are constituted by gravitational muscles (i.e., erector spine muscles, piriformis muscle, scalene muscles, suboccipital muscles, etc.) which work in synergist 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). According to this method, the analytic stretching of any muscle could be expanded to include secondary adaptative or maladaptative changes in the rest of the muscle chain, so that the analytic stretching of any individual muscle would be inefficient, if not associated with a stretching of the whole muscle chain.[13] Therefore, the GPR method employs specific strengthening and flexibility exercises in which these shortened muscle chains are stretched and strengthened.

From January to June of 2002, our research group performed a biomechanical analysis, based

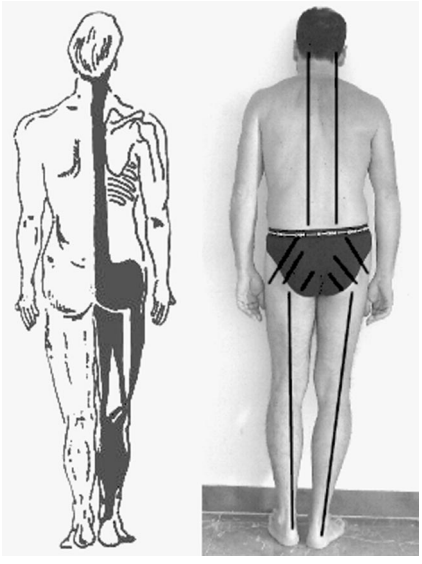

FIGURE 1 *Posterior static chain of the body.[13] The posterior static chain is constituted by the spinal posterior muscles (suboccipital muscles, cervical posterior ligament, iliocostalis, latissimus dorsi), pelvic region (pyriformis, obturators, gemellus), hamstrings, and gastrocnemius muscles.*

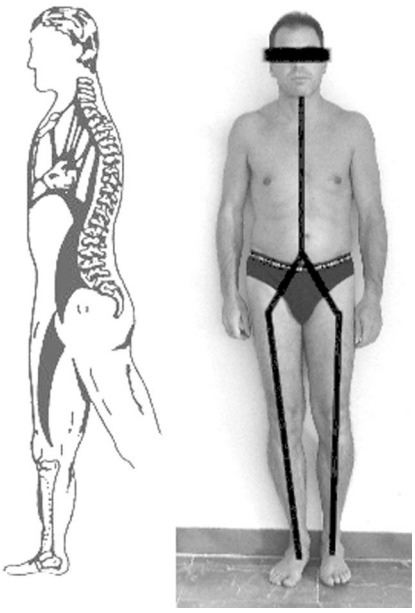

FIGURE 2 *Anterior diaphragmatic chain of the body.[13] The anterior diaphragmatic chain is constituted by the anterior deep muscle of the cervical spine, sternocleidomastoid, scalenes, anterior fascial tissues of the thoracic spine, diaphragm, psoas, adductors, and anterior tibialis muscle.*

on the principles of the GPR method, of the typical distortions frequently observed in AS patients:[2]

1. Protrusion of the jaw, caused by the shortening of both the anterior diaphragmatic chain (Fig. 2) and the posterior static chain of the body (Fig. 1).
2. Thoracic kyphosis, caused by the shortening of the anterior diaphragmatic chain (Fig. 2).
3. Loss of lumbar curve, provoked by the shortening of the posterior static chain of the body (Fig. 1).
4. Protraction and internal rotation of the scapular girdle, caused by the shortening of the anterointernal chain of the scapular girdle (Fig. 4).
5. Flexion and internal rotation of the pelvic girdle, provoked by the shortening of the anterointernal chain of the pelvic girdle (Fig. 3).

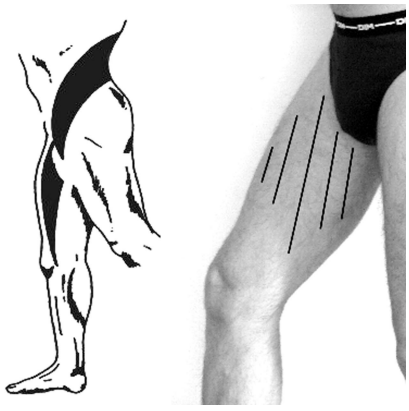

FIGURE 3 *Anterointernal chain of the pelvic girdle.[13] The anterior-internal chain of the pelvic girdle is constituted by the psoas and adductor muscles.*

Based on that analysis, our research group developed an experimental intervention in which these muscle chains were strengthened according to the principles of the GPR method. There are many years of clinical experience in Europe and South America in the management of AS with the GPR method; however, we have not found any study in the peer-reviewed literature analyzing the effectiveness of this method in AS. The GPR method probably is based primarily upon expert opinions and clinical experiences in different countries. Therefore, the aim of this study was to assess, in a randomized controlled trial, changes on mobility and functional outcomes in AS patients who are treated with the GPR method. In addition, we expose the principles of this method in the management of patients suffering from AS. To our knowledge, this is the first paper analyzing different physical therapy protocols in patients with AS.[12]

The purpose of this randomized controlled trial was to evaluate the impact of a 4-month comprehensive protocol of strengthening and flexibility exercises *vs.* conventional exercises for patients with AS on functional and mobility outcomes. We hypothesized that patients allocated to the comprehensive exercise protocol would demonstrate greater improvement in functional and mobility outcomes than those receiving conventional exercises.

MATERIALS AND METHODS

Subjects

Forty-five patients diagnosed with Ankylosing Spondylitis (AS) according to the modified criteria of New York[14] and classified into four levels of functional affectation considered by the American College of Rheumatology participated in the present trial.[15] Patients had been diagnosed and classified by their rheumatologist. In addition, functional classification for each patient was verified by the research group. All the included patients came from three hospitals in Madrid (Spain): Hospital Doce de Octubre, Hospital Severo Ochoa, and Fundación Hospital Alcorcón. Patients were excluded if they met criteria for functional class level IV, had a medical condition that impaired

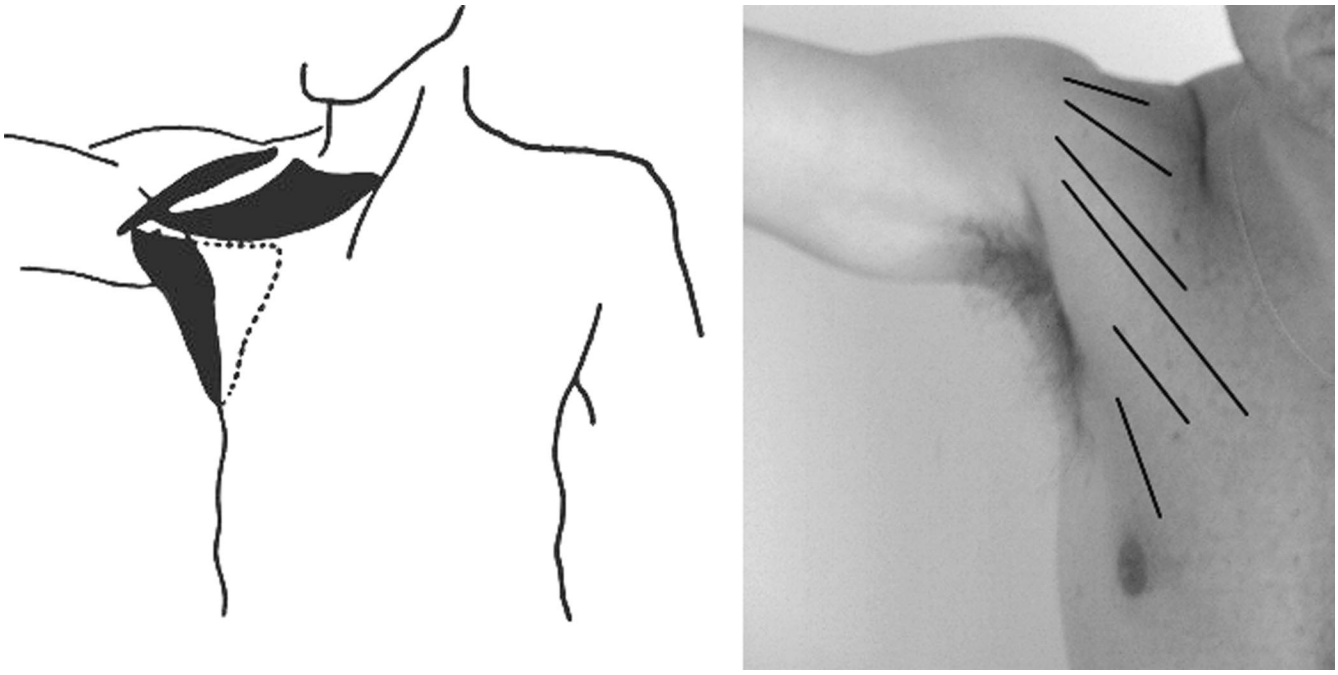

FIGURE 4 *Anterointernal chain of the scapular girdle.[13] The anterior-internal chain of the scapular girdle is constituted by subscapular and mayor pectoralis muscles.*

function more than their AS, had osteoporosis, or had a history of fractures secondary to osteoporosis. The health situation of the patients was clinically stable, without current symptoms of any other concomitant chronic disease. All patients provided informed consent prior to beginning the trial. A demographic questionnaire was completed by all patients to assess clinical and demographic data. Patients were allocated to control or experimental groups using a random numbers table. The control group was treated with a conventional protocol of physical therapy, whereas the experimental group was treated with the protocol suggested by our research group. Patients were blinded to the physical therapy intervention.

The present clinical trial was supervised by the Research and Teach Unit of Physical Therapy, Occupational Therapy, Physical Medicine and Rehabilitation of the Universidad Rey Juan Carlos. It was approved by the Ethical Committee in Clinical Research of the University.

Physical Therapy Interventions

The study lasted 4 mos. During this period, patients received a weekly group session. Each experimental or control group comprised six to eight patients. An experienced physical therapist supervised each intervention. The characteristics and experience of the therapists will be exposed later. Each session lasted an hour, and there were 15 total sessions. During the study patients were emphasized not to modify their life habits. Ninety percent of the patients had been practicing swimming-pool exercises for 2 yrs. They were told not to receive any other physical therapy intervention during the study, which was an exclusion motive. This circumstance was reminded in all sessions. All the patients were taking different types of NSAID, and the rheumatologist assured that the pharmacological treatment was the same during the trial.

The control group received a conventional physical therapy intervention, which consisted of 20 exercises employed in previous studies[9,11,16] (see 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 (PT1).

The experimental group received a different physical therapy intervention, according to the postural affectation of the AS. This intervention was based on the treatment of the shortened muscle chains, following the guideline described by the GPR method. This method employs specific strengthening and flexibility exercises in which these muscle chains are stretched and strengthened. Some of these exercises are: eccentric work of the erector spine muscles (Fig. 5), stretching of the posterior muscle chain in the pelvic region (Fig. 6), and different specific

FIGURE 5 *Eccentric work of the posterior erector muscles.*[13]

exercises aimed at stretching the shortened muscle chains (Figs. 7 and 8). This protocol was supervised by Physiotherapist 2 (PT2). Appendix 2 details the experimental intervention.

Each physical therapist had more than 2 yrs of experience in this type of treatment. Moreover, both therapists participated in developing the experimental protocol in these patients, and they had been working together for more than 4 yrs with patients suffering from AS. Therefore, the ability to motivate patients to adhere to each protocol was similar in both of them.

Outcome Measures

Each patient's evolution was closely followed, with two checks made during the study: one check at the beginning (pretreatment) and a second check at the end of the 15 sessions (posttreatment). Checks during the trial were assessed by a third assessor who was blinded to the intervention group. This assessor was a physician with many years of experience with patients suffering from AS. He was trained during 1 month to assess correctly the different outcomes. Outcome measures were assessed without any previous warm-up and before any kind of exercise. Changes in activity, mobility and functional capacity were evaluated using the following previously validated indexes from the Bath group:

- BASMI[17] (The Bath Ankylosing Spondylitis Metrology Index). The BASMI consists of five clinical measures used to assess the status of the axial skeleton: tragus to wall distance,[18,19] the modified Schöber test,[20,21] cervical rotation,[20,22] lumbar side flexion, and intermalleolar distance. A cervical goniometric device manufactured by Perfomance 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.[23] Psychometric properties of this index are good interobserver reliability on each clinical measure ($r = 0.99$; $P < 0.001$), and criterion validity (total metrology score) of $r = 0.092$, $P < 0.001$. Original authors of this index reported that these clinical measures could be analyzed independently. Jones et al subsequently established cut points on a 0–10 scale to assess a total score of the BASMI index.[24] In the present study, clinical measures were assessed independently. Patients repeated all movements three times, and the mean of these values was employed in the analysis.
- BASFI[25] (The Bath Ankylosing Spondylitis Functional Index). The BASFI consists of ten questions referring to the functional capacity of the patient with AS to perform the daily activities (see Appendix 3). All items are valued with a 10-cm horizontal visual analogue scale. The score on the BASFI is obtained from the sum of all values. Higher score of the BASFI reflects greater limitation. Psychometric properties of this index are good interobserver reliability ($r = 0.87$; $P < 0.001$) and good criterion validity.
- BASDAI[26] (The Bath Ankylosing Spondylitis Disease Activity Index). The BASDAI consists of six questions related to five symptoms during the last week: fatigue, spinal and joint pain, tenderness, and morning stiffness (see Appendix 4). All items are valued with a 10-cm horizontal visual analogue scale. The score on the BASDAI is obtained from the sum of the values from the first five questions. Higher score of the BASDAI re-

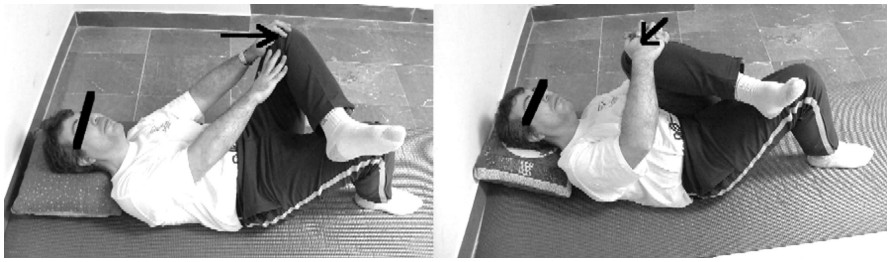

FIGURE 6 *Stretching exercise of the posterior muscle chain in the pelvic region.*[13]

flects greater disease activity. Psychometric properties of this index are good test-retest reliability ($r = 0.93$; $P < 0.001$), and face and content internal validity.

Readers might usefully explore psychometric properties of these indexes elsewhere.[27]

Statistical Analysis

Data were introduced in the SPSS package, version 11.5. Mean and standard deviation of the values were calculated for each variable. The Kolmogorov Smirnov test showed a normal distribution of the quantitative outcomes ($P > 0.05$). The intragroup data within both groups were compared with the paired *t* test. The intergroup data between both groups at the beginning of the trial were assessed with the unpaired *t* test. The intergroup comparison between the improvement (prepost scores) in both groups was also achieved with the unpaired *t* test. Statistical analysis was conducted at a 95% confidence level. A *P* value less than 0.05 was considered as statistically significant.

RESULTS

Two patients suffering from osteoporosis were excluded. On the other hand, three patients did not finish the study for personal reasons. Therefore, the analyzed sample size was 40 patients. The initial sample size in the control group was 22 patients. However, two did not finish the trial, so that the final group sample comprised 20 patients. In the same way, the initial sample size in the experimental group was 21 patients, but one did not finish the study, which means that 20 patients were finally included.

At the beginning of the study, there were no statistically significant differences in any outcome of the BASMI index (tragus to wall distance $P = 0.6$; modified Schöber test $P = 0.1$; cervical rotation $P = 0.1$; lumbar side flexion $P = 0.2$ and intermalleolar distance $P = 0.1$), as well as in the BASFI ($P = 0.4$) and BASDAI ($P = 0.7$) indexes between both groups. Furthermore, there were no statistically significant differences on gender ($P = 0.6$), age ($P = 0.6$), length of the disease ($P = 0.2$), or ACR classification ($P = 0.1$) between both study groups. It could therefore be assumed that they were comparable in all respects at the start of the trial. Demographic data corresponding to each group are given in Table 1. Clinical measures and total scores of BASFI and BASDAI indexes are summarized in Table 2.

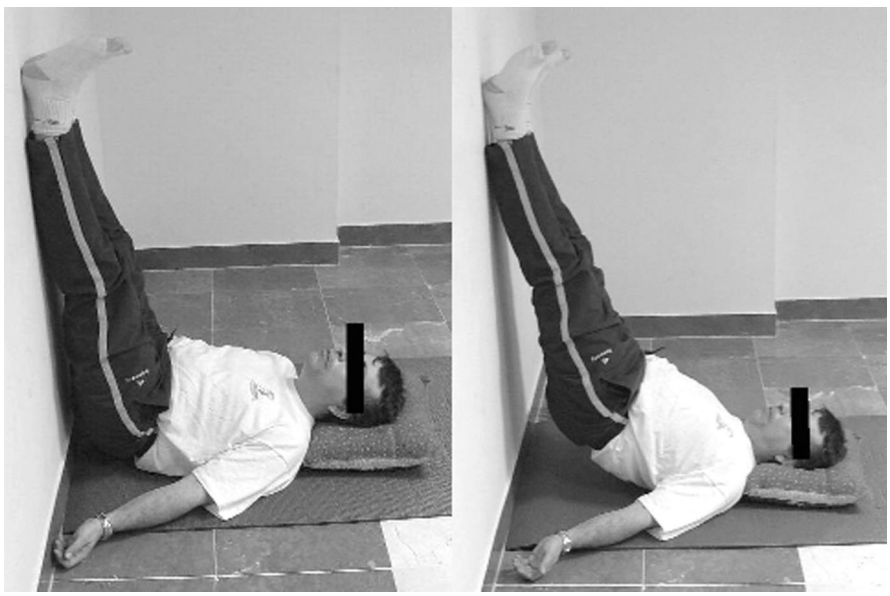

FIGURE 7 *Stretching exercise of the posterior static chain of the body wall seated.*

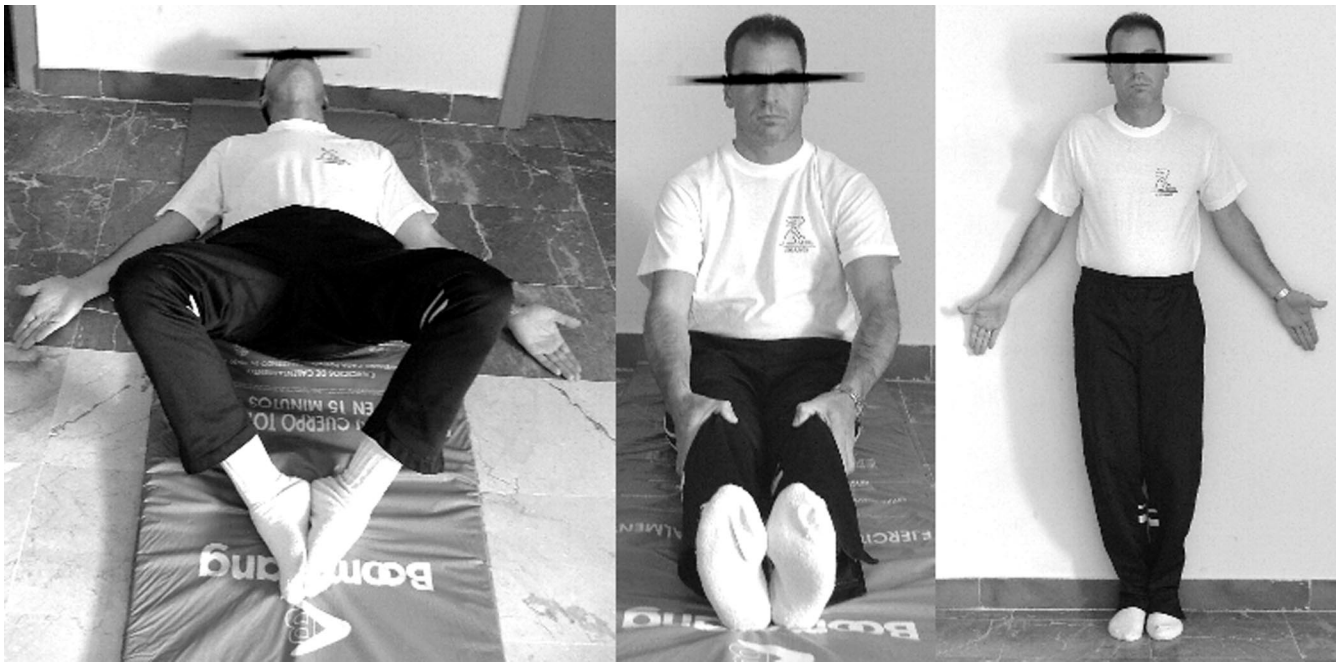

FIGURE 8 *Different exercises for stretching the shortened muscle chains in ankylosing spondylitis. a) Stretching exercise of the anterior muscle chain in supine. b) Stretching exercise of the posterior muscle chain seated. c) Stretching exercise of the anterior muscle chain standing.*

TABLE 1 Demographic data of each group

Data	Control Group	Experimental Group
Number of cases (M/F)	16/4 subjects	15/5 subjects
Age X (SD)	46 (8) yrs	45 (9) yrs
Length of the disease	7.6 yrs	8 yrs
Grade ACR (I/II/III)	5/9/6	3/10/7

M, male; F, female; Grade ACR, functional classification considered by the American College of Rheumatology; X, Mean; SD, standard deviation

The intragroup comparison (paired *t* test analysis) showed an improvement in all the outcomes, mobility measures of the BASMI index, as well as in BASFI and BASDAI indexes within both groups. In the control group, the improvement in tragus to wall distance ($P = 0.009$) and in lumbar side flexion ($P = 0.02$) was statistically significant. Although the rest of the outcomes also improved, they did not reach a significant level ($P > 0.05$). In the experimental group, the improvement in all the clinical measures of the BASMI index ($P < 0.01$) and in the BASFI index ($P = 0.003$) was statistically significant. However, the improvement in the activity index (BASDAI) was not significant. Table 2 summarizes the intragroup comparison between prepost scores within both groups.

The intergroup comparison (unpaired *t* test analysis) between the improvement (prepost scores) in both groups showed that the experimental group obtained a greater improvement than the control group in all the clinical measures of the BASMI index, except in tragus to wall distance, and in the BASFI index. Table 3 summarizes the intergroup comparison of prepost scores between both groups.

DISCUSSION

Findings

The main purpose of previous trials was to study the effectiveness of physical therapy in the management of AS. Nevertheless, the interventions were often poorly described and the exact content of the programs remains partly unclear.[12] To our knowledge, this is the first paper analyzing different physical therapy protocols in patients with AS.[12]

Our results showed that the improvement obtained with the experimental intervention was greater than the improvement obtained with a conventional physical therapy intervention. Both interventions get an improvement in all the outcome measures of the BASMI index, as well as in BASFI and BASDAI indexes. Only the improvement in tragus to wall distance and in lumbar side flexion was statistically significant in the control group. On the other hand, the improvement in all clinical measures of the BASMI index and in the BASFI index was statistically significant in the experimen-

TABLE 2 Intragroup differences in functional and clinical outcomes following intervention by group in patients with ankylosing spondylitis

Outcome Measures	Control Group				Experimental Group			
	Pretreat	Posttreat	Prepost	P	Pretreat	Posttreat	Prepost	P
Tragus to wall	6.2 (5.2) cm	4.3 (4.1) cm	1.9 (1.8) cm	0.009	7 (4.1) cm	5.1 (3.9) cm	1.9 (2.1) cm	0.001
Schöber test	2.5 (1.3) cm	2.7 (1.3) cm	0.2 (0.5) cm	NS	1.8 (1.3) cm	2.4 (1.1) cm	0.6 (0.6) cm	0.001
Cervical rotation	54° (15)	57° (9)	3° (10)	NS	46° (21)	57° (18)	11° (15)	0.005
Lumbar side flexion	4.8 (2.3) cm	6.2 (2.6) cm	1.4 (1.3) cm	0.02	3.9 (2.5) cm	6.3 (2.5) cm	2.4 (1.4) cm	0.001
Intermal. distance	86.1 (8.2) cm	88.5 (8.2) cm	2.4 (8.4) cm	NS	81.7 (11.2) cm	90.8 (11.2) cm	9.1 (8) cm	0.002
Basfi	47 (19)	46.5 (21)	0.5 (8.7)	NS	51.8 (20.8)	45.7 (20.6)	6.1 (8)	0.003
Basdai	28.5 (10)	26.2 (8.6)	2.3 (5.8)	NS	27.6 (9.1)	26 (11.3)	1.6 (5.7)	NS

Values are expressed in centimeters (cm) in tragus to wall distance, Schöber test, lumbar side flexion and intermalleolar distance; in degrees (°) in cervical rotation; and total scores in BASFI and BASDAI indexes.

Pretreat, pretreatment values of each variable, values are expressed by mean (standard deviation); Posttreat, posttreatment values of each variable, values are expressed by mean (standard deviation); Prepost value, values are expressed by mean (standard deviation); Internal distance, intermalleolar distance. *P* values come from dependent samples Student's *t* test analysis. NS, no significance.

tal group. The intergroup comparison between pre-post scores between both groups showed that the experimental group obtained a greater improvement than the control group in four clinical measures of the BASMI and in the BASFI index. Despite the apparent differences between groups at the beginning of the trial, the intergroup comparison (based on the unpaired *t* test) did not reveal any significant differences at the beginning of the trial. Therefore, it might be assumed that the experimental intervention was the responsible of the greater improvement obtained in the experimental group.

Based our results, we might assume that the treatment of the shortened muscle chains (Figs. 1–4), according to the GPR method, might be more beneficial than conventional interventions in patients with AS. We have to emphasize that the difference between these interventions is the integration of the affected muscles in different muscle chains shortened in these patients. The analytic stretching of any of these muscles could be expanded to include secondary adaptative or maladaptative changes in the rest of the muscle chain, so that the analytic stretching of any gravitational muscle would be inefficient. Further studies are required to elucidate the role of the muscle chains in AS patients.

Another purpose of the present trial was to compare the results of the experimental group with the results reported by previous papers. Although previous studies[9,11,16,28,29] have analyzed the effects of the conventional intervention received by our control group, differences among patients, number of sessions, outcome measures, scores at the beginning of the trial, and other such variables make it difficult to make this comparison.

A factor that influences the results is the group session. A group session implies positive reinforcement and an increase in the patients' self-esteem when coming by themselves and finding support from other people with the same disease. There is some evidence suggesting that spinal mobility obtains a greater improvement with a group physical therapy program than with home exercises.[9,11,12,30] Baumberger mentioned mutual encouragement, reciprocal motivation, and exchange of experience as some advantages of group physical therapy intervention.[31] Therefore, future studies evaluating the therapeutically effects of different physical therapy protocols should be performed in group sessions.

Outcome Measures

In the present study, changes in activity, mobility, and functional capacity were evaluated using the previously validated indexes from the Bath group: the BASMI,[17] BASFI[25], and BASDAI[26] in-

TABLE 3 Intergroup comparison of the improvement (prepost scores) between both groups

Outcome Measures	Prepost Scores of Control Group	Prepost Scores of Experimental Group	F* (*P* score of Levene)	*P*
Tragus to wall distance	1.9 cm (95% CI 2.8, 1)	1.9 cm (95% CI 2.9, 0.9)	0.6 (0.8)	NS
Modified Schöber test	0.2 cm (95% CI 0.5, −0.1)	0.6 cm (95% CI 0.9, 0.3)	0.1 (0.7)	0.04
Cervical rotation	3º (95% CI 7, −1)	11º (95% CI 18, 4)	3.5 (0.06)	0.04
Lumbar side flexion	1.4 cm (95% CI 2, 0.8)	2.4 cm (95% CI 3.1, 1.7)	0.18 (0.6)	0.02
Intermalleolar distance	2.4 cm (95% CI 6.3, −1.5)	9.1 cm (95% CI 12.7, 5.5)	0.03 (0.9)	0.01
Basfi index	0.5 (95% CI 4.5, −3.5)	6.1 (95% CI 9.8, 2.4)	0.26 (0.6)	0.04
Basdai index	2.3 (95% CI 5, −0.4)	1.6 (95% CI 4.3, −1.1)	0.002 (0.9)	NS

Values are expressed in centimeters (cm) in tragus to wall distance, Schöber test, lumbar side flexion and intermalleolar distance; in degrees (º) in cervical rotation; and total scores in BASFI and BASDAI indexes.Data are expressed by mean (95% confidence interval).* F, Levene test to assess the homogeneity of the variance.*P* values come from independent (unpaired) samples Student's *t* test analysis.NS, not significant

dexes. The clinical measures considered in the BASMI index reflect the axial status of patients with AS.[17] This index had demonstrated sensitivity to change across the whole disease spectrum including patients with disease of long duration[17] (see psychometric properties of BASMI index in Methods section). Although Jones et al.[24] established cut points on a 0–10 scale to assess a total score of the BASMI index, authors of the present trial preferred to assess independently each clinical measure. Although the BASMI has very good qualities, Heikkila et al.[29] reported that several measures are not sensitive and that others are. They suggested the finger to floor distance, chest expansion, thoracolumbar rotation, and lateral flexion as the most sensitive mobility measures. Other measures that might be used, but at a lower level of sensitivity, are cervical rotation and intermalleolar distance.[29] Finally, they did not suggest the Schöber test, thoracolumbar flexion, or tragus to wall distance.[29] 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 (Schöber test and tragus to wall distance). Therefore, conclusions from the study of Heikkila et al.[29] suggest changes in the mobility measures of the BASMI index. The reason to assess the BASMI index is that it is the only validated index (criterion validity and interobserver reliability determined) in the peer-reviewed literature that assess the status of the axial skeleton in patients with AS. However, that situation does not refute the necessity of revision of these clinical measures.

The BASFI index[25] showed to be sensitive to demonstrate an improvement in the functional ability in these patients (see psychometric properties of BASFI index in Methods section). Recently, Falkenbach et al.[32] have reported that the BASFI index is also applicable to older patients experiencing AS. Moreover, Eyres et al.[33] reported that the BASFI index had more items displaying differential item functioning than the Dougados Functional Index. The problem with the Dougados Functional Index includes the fact that patients often find some questions difficult to answer without qualification. Other functional indexes (HAQ-S, SIP) that have been used in previous studies[8,9] are not sensitive to detect changes in patients with AS.

The items of the BASDAI index[26] represent the five major symptoms experienced by patients with AS. Length of time in morning stiffness was included in this index, but this item is not used to calculate the total score (see psychometric properties of BASDAI index in Methods section). In the present study, changes in the BASDAI index after both interventions were not statistically significant. This situation could be caused by the small simple size. A greater number of patients might show statistically significant differences in prepost scores within both groups.

Further Research

The scientific literature shows different papers which have analyzed the therapeutically effects at 8 mos,[34] 9 mos,[35], and 3 yrs[11] after the intervention. Therefore, some questions remain to be answered. First, how long will the improvement maintain? The improvement would probably remain longer with the experimental protocol, since better results were achieved with this intervention. But, will the effect disappear at the same rate in both groups? Will the experimental group maintain a greater proportion of clinical improvement? That is why we propose to continue the study assessing patients after 6 mos and 2 yrs after the intervention.

Limitations

The small sample size and the absence of a control group, without any physical therapy intervention, are some of the most significant limitations of this study. We have to consider that this trial has been comparative, taking an active control

group treated with a physical therapy intervention analyzed in previous papers.[9,11,16,28,29] Obviously, type 2 errors could have happened, so it is recommended to repeat the same procedure with a greater number of patients and with a control group without any therapeutically intervention

Another topic to discuss is the possible influence of some clinical features such as age, sex, work, length of the disease, and other circumstances. Any randomized controlled trial depends on the demographic and clinical characteristics of the sample, so it is difficult to obtain similar patients in different studies performed in different countries.

Finally, we did not consider the effects of the pharmacological treatment, which we know that helped patients during the study. All patients had been taking NSAID treatment for at least 10 yrs (controlled by their rheumatologist); however, during the trial all patients were asked not to modify their pharmacological treatment. On the other hand, something we positively thought could affect the results was the swimming-pool exercise. The whole sample size (90%) had already been doing it for several years and it was included in their habitual practice. Therefore, it was not modified because the exercises were the same in all patients, so that we considered that the obtained improvement would affect both groups in the same way.

CONCLUSION

The experimental group obtained a greater improvement than the control group in all clinical measures, except in tragus to wall distance, and in the functional index (BASFI). The experimental protocol developed by our research group, based on the GPR method and specific strengthening and flexibility exercises of the shortened muscle chains, offers promising results in the management of patients suffering from AS. Further trials are required.

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APPENDIX 1: Conventional physical therapy intervention

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

APPENDIX 2: Experimental physical therapy intervention

In this appendix we will expose the scheme of the experimental intervention (divided into six phases) and the exercises to stretch the specific muscle chains. More details about these exercises may be found elsewhere[2,13]. (*) 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 (1):9–14.

Phase	Purpose of Each Phase	Exercises	Repetitions
1. General warm-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 (*).	2 series of 8 repetitions each one
2. Specific warm-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 (Fig. 6).	2 series of 8 repetitions each one
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 one
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 (Fig. 8a). 2. Stretching exercise of the posterior muscle chain seated (Fig. 8b). 3. Stretching exercise of the posterior muscle chain seated on the wall (Fig. 7). 4. Stretching exercise of the anterior muscle chain standing (Fig. 8c). 5. Eccentric work of the erector spine muscles (Fig. 5).	Allstretching postures have to be maintained during 3–4 mins each one
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 one
6. Cool–down	This phase will consist on slightly neck and thoracic exercises. All exercises will be performed walking	1. Cervical flexo-extension. 2. Cervical lateral-flexion. 3. Cervical rotation. 4. Circular motion of the scapular girdle.	1 series of 5 repetitions each one

APPENDIX 3: The Bath Ankylosing Spondylitis Functional Index: The BASFI index[25]

Please draw a mark on each line below to indicate your level of ability with each of the following activities during the last week.

Putting on your socks or tights without help or aids (e.g., sock aid).
Easy___ Impossible___

Bending forward from the waist to pick up a pen from the floor without an aid.
Easy___ Impossible___

Reaching up to a high shelf without help or aids (e.g., helping hand).
Easy___ Impossible___

Getting up out of an armless dining room chair without using your hands or any other help.
Easy___ Impossible___

Getting up off the floor without help from lying in your back.
Easy___ Impossible___

Standing unsupported for 10 mins without discomfort.
Easy___ Impossible___

Climbing 12–15 steps without using a handrail or walking. One foot on each step.
Easy___ Impossible___

Looking over you shoulder without turning your body.
Easy___ Impossible___

Doing physically demanding activities (e.g., physiotherapy exercises, gardening, or sports).
Easy___ Impossible___

Doing a full day of activities, whether at home or at work.
Easy___ Impossible___

APPENDIX 4: The Bath Ankylosing Spondylitis Disease Activity Index: The BASDAI index[26]

Please place a mark on each line below to indicate your answer to each question, relating to the past week.

How would you describe the overall level of fatigue/tiredness you have experienced?
___ None ___ Very severe

How would you describe the overall level of AS neck, back, or hip pain you have had?
___ None ___ Very severe

How would you describe the overall level of pain/swelling you have had in joints other than the neck, back, or hips?
___ None ___ Very severe

How would you describe the overall level of discomfort you have had from any areas tender to touch or pressure?
___ None ___ Very severe

How would you describe the overall level of morning stiffness you have had from the time you wake up?
___ None ___ Very severe

How long does your morning stiffness last from the time you wake up?
___ 0 hrs ___ 1/2 ___ 1 hr ___ 1 1/2 ___ 2 or more hrs

Item 6 is not employed to assess the total score of the BASDAI index.