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Improvement in pain intensity, spine stiffness and mobility during a controlled individualized physiotherapy program in ankylosing spondylitis

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Suggested Reviewers:	Tamás Bender bender@mail.datanet.hu

Authors' Response to Reviewers' Comments
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Dear Prof Lemmel

Thank you and the reviewer for the review, and the chance for revising our manuscript.

Concerning the correction of 'disease duration' issue, we agree with the Reviewer. It is now clarified in the text and in Table 1, and so, the related calculations have been omitted from the manuscript.

The percentage data have been also clarified (There were patients reporting more than one location of pain and stiffness).

All the other corrections requested have been now performed.

We hope that the revision is satisfactory and our paper is now acceptable for publication.

Sincerely yours,

Zsuzsanna N. Gyurcsik

Improvement in pain intensity, spine stiffness and mobility during a controlled individualized physiotherapy program in ankylosing spondylitis

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Abstract

Objective: Physical therapy in ankylosing spondylitis (AS) is important for maintaining or improving mobility, fitness, functioning, and global health. It also plays a role in the prevention and management of structural deformities. In this study we assessed the functional status of AS patients in relation to disease duration and activity. Furthermore, in volunteering patients we analyzed the efficacy of a controlled, individualized physiotherapeutic program.

Patients and methods: Altogether clinical data of 75 AS patients were retrospectively analyzed. Anthropometrical data, duration since diagnosis and disease activity, pain intensity, tender points, sacroiliac joint involvement determined by X-ray, functional condition and physical activity level were recorded. Subjective, functional and physical tests were performed. Out of the 75 patients, 10 volunteered to undergo a complex physical exercise program twice a week for 3 months. The program included 1.5 hours of general posture reeducation, manual mobilization of the spine, and pelvic-, upper and lower extremity exercises, stretching with joint prevention strategies and functional exercises.

Results: In AS, pain intensity recorded on a 10 cm visual analog scale (VAS), BASFI, BASDAI, modified Schober-index, chest expansion and occiput-to-wall distance values showed significant correlation with disease activity. The 3-month physical therapy improved several subjective and functional parameters, and markedly reduced pain intensity and spine stiffness.

Conclusion: A complex, individualized physical therapy program may be useful and should be introduced to AS patients in order to maintain and increase spine mobility, preserve functional capacity, decrease the pain and stiffness.

Key words: ankylosing spondylitis, pain, stiffness, tender points, mobility, physiotherapy

Introduction

Ankylosing spondylitis (AS) is a chronic immuno-inflammatory disease that affects the axial skeleton and sometimes also the peripheral joints. Pathologic alterations occur in synovial and cartilaginous joint and in sites of tendon and ligament attachment to bone [1,2].The most common and characteristic initial symptom of AS is chronic low back pain of insidious onset [3]. Most structures and tissues found in the low back, hip and pelvic areas are capable of producing symptoms. Sacroiliac pain may irradiate to the back, buttocks, groin and lower extremity similarly to pain patterns originating from other lumbosacral regions (Table 1). However, there is still a delay of years from the first symptoms until the final diagnosis is established [4]. Radiological changes are often detectable only years after the onset of AS, despite the presence of inflammation and clinical manifestations, such as pain and stiffness (Figure 1) [5-7]. Inflammatory low back pain in AS is usually of insidious onset, dull in character, and difficult to localize. It is usually felt deep in the gluteal area or sacroiliac region. The pain can be quite severe at this early stage, and may be accentuated on coughing, sneezing or sudden twist of the back. The pain can be unilateral or intermittent, later becomes persistent or bilateral and the lumbar area becomes stiff and painful [3,8]. Fatigue can frequently appear related to pain and stiffness [9].

The second early symptom is back stiffness that is worse in the morning after sleeping and prolonged period of inactivity. Some patients may complain only about back stiffness or musculotendinous tender points (Table 1). Involvement of the thoracic spine and enthesitis at costosternal and manubriosternal joints may cause chest pain. Stiffness and pain in the cervical spine generally occur in the early stages of the disease and tend to develop after some years. The involvement of other joints, such as the hips may cause flexion contractures eventually leading to characteristic, rigid gait with flexion with knee to maintain erect posture

(Figure 1) [6,10-12]. Therefore, the long-term follow-up of AS patients needs to include repetitive assessments of inflammation, pain, structural changes and deterioration of function [13,14].

Physical therapy in AS may be important for the maintenance or even improvement of spinal and articular mobility, fitness, functioning, and global health. It also plays a role in the prevention and management of AS-related musculoskeletal deformities [14-18]. Physiotherapy also strengthens muscles of the trunk, legs, back and abdomen [18,19]. Table 2 presents an overview of physiotherapeutic modalities for AS.

In this study, we retrospectively evaluated the functional status of AS patients in relation to disease duration and activity. Furthermore, in a group of volunteering AS patients we conducted a prospective study by applying a controlled and individualized physiotherapy program.

Patients and methods

Retrospective analysis of AS patients

In the first part of the study, clinical data of AS 75 patients (55 men and 20 women) undergoing follow-ups at the Department of Rheumatology of University of Debrecen Medical and Health Sciences Center were retrospectively analyzed. All patients had definite AS according to the modified New York criteria [20]. Informed consent was obtained from all participants.

Anthropometrical data, duration since diagnosis and disease activity (BASDAI), pain intensity on a VAS scale, smoking habits, drugs history, sacroiliitis stage assessed by X-ray, functional capacity (BASFI), levels of physical activity were recorded. Functional and

physical tests were performed by the same physician as described below. None of the patients had history of any cardiopulmonary diseases.

Evaluation of individualized physiotherapy program

Ten out of the 75 AS patients described above including 5 men (age: 54.8±14.9 years, BMI: 28.1±2.7 kg/m^2) and 5 women (age: 47.6±13.1 years, BMI: 26.3±6.1 kg/m^2) volunteered to become into the second part of the study. This part included a controlled, individualized physical therapy program.

Physical exercise (2 times per week for 3 months) consisted of 1.5 hours of general posture reeducation, manual mobilization of the spine, and pelvic-, upper and lower extremity exercises, stretching of the shortened muscles (mainly back, lumbar spine, hips and shoulders) with joint prevention strategies, as well as functional exercises.

Subjective, functional and physical tests described below were performed before and after the 3-month physiotherapy program.

Subjective, functional and physical tests

Degree of pain intensity and disease activity were recorded by patients on a 10 cm horizontal visual analog scale (VAS).

Bath Ankylosing Spondylitis Functional Index (BASFI) and Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) were used for the assessment of functional ability and disease activity in AS, respectively [21,22].

With respect to physical tests, the participants were assessed in a clinic-based setting by a trained observer. The modified Schober index, chest expansion, lumbar lateral flexion,

occiput-to-wall distance and finger-to-floor distance were assessed [23,24]. Modified Schober index (MSI) is a distance between two marks placed 15 cm apart in standing (10 cm proximal and 5 cm distal to the PSIS) following maximal forward flexion of the spine. Larger difference indicates greater lumbar movement, measured by a plastic tape. Chest expansion (CE) is measured with a tape measure in cm, placed circumferentially around the chest wall at the fourth intercostal space. Lumbar lateral flexion (LLF) is a distance between tip of ipsilateral middle finger and floor following maximal LLF, maintaining heel contact the floor and without trunk rotation. Smaller distance indicates greater movement, measured by a retractable plastic tape measure. Occiput-to-wall distance (OWD) is the horizontal distance between occiput and wall, standing with heels and buttocks against the wall, knees extended and chin drawn in. Larger distance indicates worse spinal/upper cervical posture, measured by a retractable plastic tape**.** Finger-to-floor distance (lumbar forward flexion; FFD) is the distance between tip of right middle finger and floor following maximal lumbar flexion, whilst maintaining knee extension. Smaller distance indicates greater movement, measured by a retractable plastic tape measure.

Each movement was practiced once before the range of motion was recorded. All baseline and repeat appointments were arranged for the same time.

Furthermore, stiffness areas and tender points were detected subjectively [8].

Statistical analysis

Data are presented as means ± standard deviation (S.D.). In the first part of the study correlations among variables were evaluated by Pearson correlation analysis, based on linear regression. In the second part of the study the values before versus after the treatment were compared and evaluated by Wilcoxon signed rank or paired t-test, depending on normality of data distribution. A p value of <0.05 were considered as statistically significant.

Results

Retrospective analysis of AS patients

Evaluating the subjective pain parameters we found that the pain and stiffness was the strongest in back of patients in 66%, in lower back in 39% and in neck in 43% of the cases. In several cases more than one location was affected (4 patients reported all of these three locations).

Table 3 summarizes the age, duration since diagnosis and disease activity as well as functional index values of examined AS patients of this study.

Both duration since diagnosis (2-50 years) and activity of the disease (1-98 mm) varied in wide range, and did not show obvious gender differences. However, in this study, men were presented in higher numbers (55 vs 20) and showed wider distribution in age. Mean values of BASFI were slightly higher in men than in women (4.64±2.84 vs 4.25±2.95, p=NS). In contrast, BASDAI values were found to be higher in women compared to men (4.01±2.81 vs 3.49±2.35, p=NS) (Table 3).

Using Person correlation analysis, pain intensity, BASFI, BASDAI, MSI, CE and OWD values showed significant correlations with activity of the disease (Table 4).

Evaluation of individualized physiotherapy program

The individualized physiotherapy program was easily performable for the patients according to their subjective feedback.

The number of tender points markedly decreased during and after the physiotherapy program. Except for the vertebral processus spinosus in the cervical spine, all the examined tender points decreased after exercise. The most expressed decrease was found in the number of the following tender points: angulus superior of the scapula, manubriosternal joint, costosternal joints, processus xyphoideus and in the sacroiliac joints (Table 5).

Prior to the physiotherapy program, pain and stiffness in the back and lower back was present in 9 out of 10 patients (90%), while those in the cervical spine were present in 7 out of 10 patients (70%). After completing the exercise program, pain and stiffness in the back/lower back or in the cervical spine decreased in 4 and 3 patients, respectively (Table 5).

Subjective, functional and physical test results are presented in Table 6. Disease activity showed a slight, non-significant decrease after exercise program. Decrease of pain intensity was much expressed, however, also did not reach the level of significance. Mean BASFI and BASDAI values decreased by 15-18%, while mean MSI values increased by 30%. CE almost doubled after exercise (2.67±1.32 cm versus 4.53±0.83 cm, $p<0.001$). Mean LF values increased by 35%, while OWD values did not change at all. Mean FFD values decreased by almost 40% after the exercise program (Figure 2, Table 6).

Discussion

Physiotherapy is widely recognized as the one of the most important tool in the non-pharmacological management of AS [16,18]. There has been some evidence that exercise alone can produce adequate symptom relief in many patients with AS. Significant benefit from exercise and education can be demonstrated over relatively short or long periods and other therapies have also been shown to increase mobility and functionality [16,18].

Physiatrists should become involved in prevention, treatment and rehabilitation programs based on correct, early diagnosis [1,14,19].

In our study, first we retrospectively assessed pain intensity (VAS), BASFI, BASDAI, MSI, CE and OWD values in AS patients. All these parameters correlated with disease activity. Out of these 75 patients, 10 volunteers were included in the second part of the study. In this phase, the 10 AS patients underwent a complex physical exercise program that included exercise twice a week for 3 months. This therapy improved several subjective and functional parameters and also reduced the pain and stiffness.

Several studies verified that in AS, spinal mobility measures were associated with physical function. Vesovic-Potic et al [25] reported significant correlation between disease duration, symptoms duration and BASFI. The efficacy of various physiotherapy programs has been assessed by several groups [12,14,15,26-28] concluding that exercise programs are important and useful part of the complex therapy of AS-

Dagfinrud et al [14] recently reviewed the available body of evidence on the efficacy of physiotherapy interventions in AS. This meta-analysis suggests that an individual home-based or supervised exercise program is better than having no intervention. Moreover, a supervised group physiotherapy is better than a home exercise. A combined inpatient spa-exercise therapy followed by group physiotherapy could be much more effective that the group physiotherapy alone.

It has been demonstrated that by intensive rehabilitation courses it is possible to prevent deterioration of spinal function, however fitness in AS patients irrespective of disease duration [12]. The efficacy of intensive inpatient physiotherapy has been reported by changes in subjective and functional parameters, from which OWD, CE and FFD showed the greatest improvement [11]. According to Heikkila et al [27], the most sensitive spinal measurements were finger to floor distance, chest expansion and thoracolumbar lateral flexion while the

Schober index and OWD were not sufficiently sensitive. Moreover, changes in the measurements correlated significantly with radiological spinal changes [27].

Ince et al [28] conducted a randomized controlled trial. Subjects were assigned to either a group that received an exercise program or to a control group. The exercise program consisted of 50 minutes of multimodal exercise, including aerobic, stretching and pulmonary exercises, 3 times a week for 3 months. Subjects in both groups received medical treatment for AS. The results of the exercise group for chest expansion, Schober index and OWD were significantly better than in control group after the exercise period. The spinal movements of exercise group improved significantly by the end of the program.

In the randomized controlled trial by Fernandez-de-las-Penas et al [26] a conventional physiotherapeutic intervention (20 spinal and chest exercises and stretching of the shortened muscles) and their own protocol (based on the postural affectation of the AS, the shortened muscles were treated by stretching during 4 months) were compared. Both groups showed an improvement in all mobility measures, as well as in BASFI and BASDAI, but their own protocol showed a better improvement.

In conclusion, the effects of physical therapy is indisputable either in short term or in long term. Many types of therapeutic modalities are known in physical therapy, but the aims are the same: maintaining and increasing the mobility and functionality with joints prevention strategies, decreasing the pain and stiffness, informing the patients and improving the quality of their life. Our complex physiotherapeutic program was effective to reduce pain, stiffness and to improve functional parameters. However, further studies are needed to clarify the beneficial impact of various physiotherapeutic programs and increase their efficacy.

Tables

Table 1. Tender points and typical posture in Ankylosing Spondylitis

Pain, Tenderness	**Typical posture**
Ischial tuberosities	Forward sloop of the neck
Greater trochanters	Loss of lumbar lordosis
Costochondral and manubriosternal junction	Thoracic kyphosis
Anterior-superior iliac spines	Protuberant abdomen
Iliac crest	Flattened anterior chest
Calcanei	Flexion at the hip and knee
Tibial tubercle	
Pubic symphysis	
Vertebral spinosus processes	

Table 2. Physiotherapeutic modalities for Ankylosing Spondylitis

Proposed treatments	**Our applied treatments, techniques**	**Aims**	**Forms of treatments**
Exercise training *Manual therapy* *Stretching* Massage Hydrotherapy Spa therapy Electrotherapy Alternative therapy: acupuncture Education Appropriate sports	*Global posture reeducation,* *Manual mobilization of the spine and pelvic,* *Upper and lower extremity exercises,* *Stretching of the shortened* *Functional exercises with joint prevention strategies*	*To diminish* the pain, tenderness, fatigue *To increase and maintain* the mobility (spine and extremities), strength and power of the muscles, functionality *To stimulate and motivate* the patients to continue exercising	Supervised exercises for individual or groups patients Unsupervised exercises-based on a predefined program

Table 3. Age, duration since diagnosis and disease activity as well as functional index values of AS patients.

	Men (n=55)	**Women** (n=20)
Age [year]	44.63 ± 11.23 (18 – 75)	43.10 ± 8.68 (31 – 56)
Disease since diagnosis [year]	14.88 ± 10.91 (2 – 50)	13.57 ± 9.42 (2 – 32)
SI average stage (grade 1-4)	3.19 ± 0.77 (1 – 4)	2.4 ± 1.04 (1 – 4)
Disease activity [cm on VAS]	42.5 ± 27.13 (1 – 98)	41.58 ± 28.81 (2 – 98)
Pain intensity [cm on VAS]	38.51 ± 25.09 (1 – 86)	42.7 ± 28.28 (7 – 99)
BASFI [cm on VAS]	4.64 ± 2.84 (0.19 – 10)	4.25 ± 2.95 (0.14 – 8.98)
BASDAI [cm on VAS]	3.49 ± 2.35 (0.25 – 8.2)	4.01 ± 2.81 (0.23 – 9.56)
MSI [cm]	2.52 ± 1.84 (0.5 – 6)	3.05 ± 2.21 (0.3 – 6.2)
CE [cm]	2.73 ± 1.29 (1 – 6)	3.01 ± 1.31 (1.2 – 6)
OWD [cm]	6.74 ± 7.81 (0 – 24.5)	6.07 ± 9.51 (0 – 26)

means ± S.D., (lowest – highest values)

Table 4. Correlation between tested parameters and disease activity

	Disease activity
SI average state	r=0.117, p=0.339
Pain intensity	r=0.887, *p<0.001*
BASFI	r=0.685, *p<0.001*
BASDAI	r=0.826, *p<0.001*
MSI	r=0.307, *p=0.021*
CE	r=0.336, *p=0.011*
OWD	r=0.387, *p=0.003*

Pearson correlation analysis; r = regression coefficient

Table 5. Number of patients with marked tender points before and after the physiotherapeutic program

	Patients (n=10)	
	Before	**After**
Vertebral processus spinosus on neck	8	9
Vertebral processus spinosus on thoracal region	7	5
Vertebral processus spinosus on lumbar region	6	4
Tuberculum majus of the humerus	3	2
Processus coracoideus of the scapula	6	5
Angulus superior of the scapula	3	0
Manubriosternal joints	4	2
Costosternal joint	4	1
Processus xyphoideus	4	1
Sacroiliacal joint	5	1
Trochanter major of the femur	0	0

Table 6. Subjective, functional and physical test results in patients before and after physiotherapeutic program

	Before	**After**	**After/Before ratio**	**Before vs After p value**
Disease activity [cm on VAS]	38.7 ± 24.66	26.7 ± 23.61	0.53 ± 0.33	p = 0.281
Pain intensity [cm on VAS]	41.1 ± 24.77	24 ± 21.16	0.44 ± 0.32	p = 0.114
BASFI [cm on VAS]	4.33 ± 2.61	3.81 ± 2.71	0.82 ± 0.26	p = 0.668
BASDAI [cm on VAS]	4.36 ± 2.62	3.94 ± 2.6	0.85 ± 0.11	p = 0.724
MSI [cm]	2.36 ± 1.85	2.84 ± 2.17	1.31 ± 0.6	p = 0.307
CE [cm]	2.67 ± 1.32	4.53 ± 0.83	2.01 ± 0.77	*p<0.001*
LF [cm]	4.1 ± 3.31	5.05 ± 3.53	1.35 ± 0.51	p = 0.543
OWD [cm]	6.7 ± 5.99	6.55 ± 5.89	0.97 ± 0.03	p = 0.956
FFD [cm]	17.95 ± 11.8	10.6 ± 7.72	0.61 ± 0.2	p = 0.117

n=10, means ± S.D

Figure legends

Figure 1.

The symptoms in Ankylosing Spondylitis. Relation of pain, stiffness and mobility reduction as a vicious cycle

Figure 2.

Changes of values [cm] of modified Schober test, chest expansion, wall-occiput distance and finger-floor distance tests before and after the 3-month physiotherapeutic program (data used from Table 6).

MSI = modified Schober index; CE = chest expansion; OWD = occiput-to-wall distance; FFD = finger-to-floor distance

n=10, * $p<0.001$ vs before (Wilcoxon signed rank test)

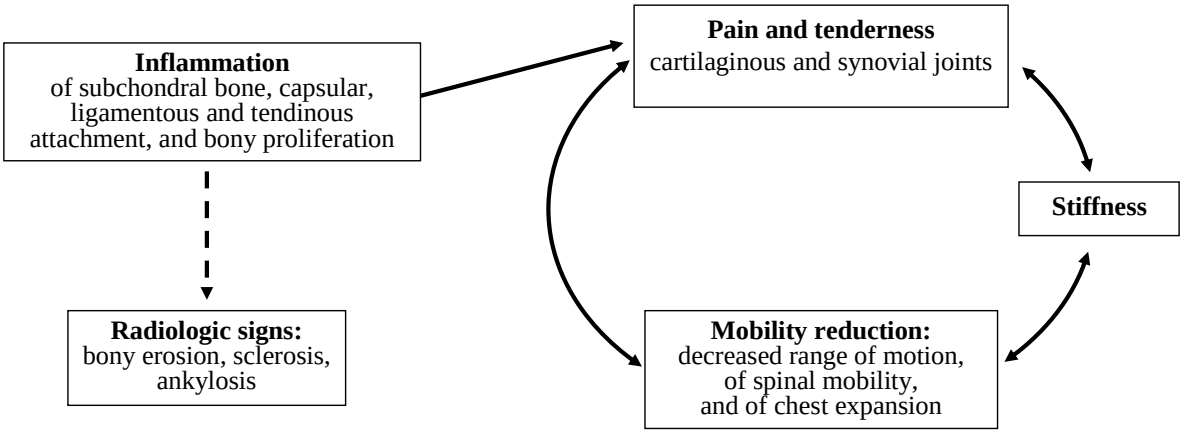
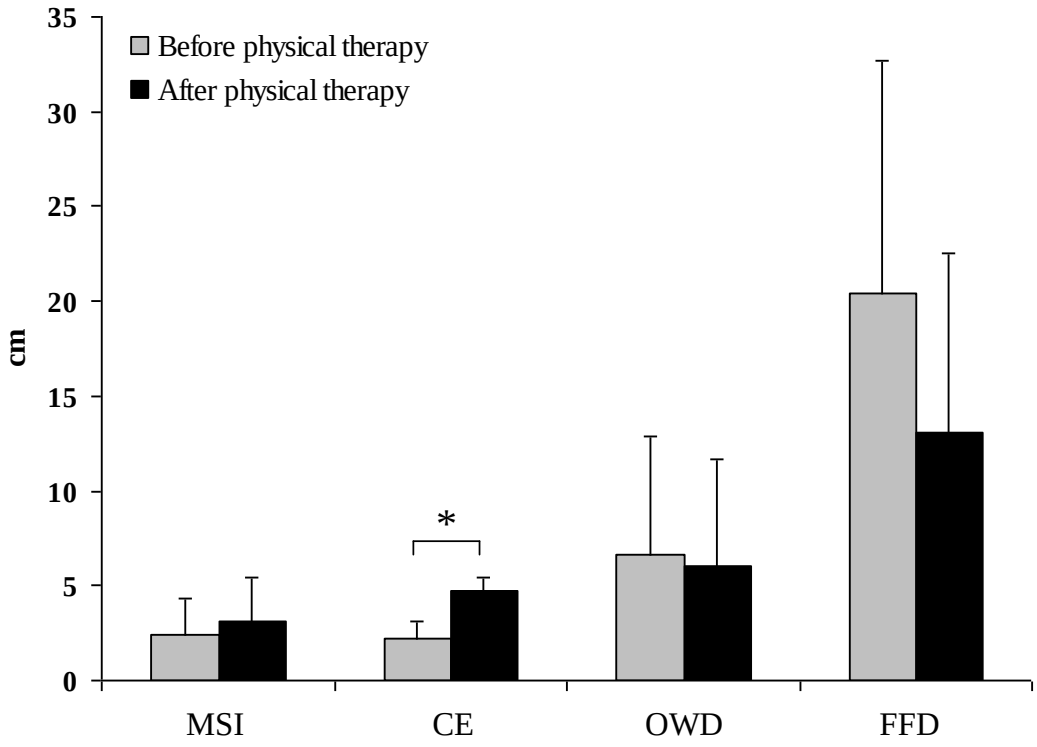

Inflammation
of subchondral bone, capsular, ligamentous and tendinous attachment, and bony proliferation
Pain and tenderness
cartilaginous and synovial joints
Stiffness
Mobility reduction:
decreased range of motion, of spinal mobility, and of chest expansion
Radiologic signs:
bony erosion, sclerosis, ankylosis

Figure 1.


35
30
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Before physical therapy
After physical therapy
*
MSI
CE
OWD
FFD

Figure 2.

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