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ORIGINAL RESEARCH

Medicine Science International Medical Journal

Medicine Science 2019;8(3):613-9

Postural stability and the relationship with enthesitis in ankylosing spondylitis: A cross-sectional study

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Received 19 January 2019; Accepted 10 March 2019
Available online 04.04.2019 with doi:10.5455/medscience.2019.08.9030

Abstract
This study aims to investigate the static and dynamic postural stability in ankylosing spondylitis (AS), and to evaluate their relationships with clinical parameters, postural measurements, and enthesitis. Sixty-four patients with AS (37 males, 27 females; mean age 41.06±8.89 years) and 42 healthy individuals (23 males, 19 females; mean age 38.45±8.46 years) were involved in the study. The static and dynamic postural stability of all participants were assessed using the Biodex Balance System. Patients' posture was evaluated using chest expansion, tragus-wall distance, and the modified Schober's test. The disease activity (Bath Ankylosing Spondylitis Disease Activity Index: BASDAI), functional status (Bath Ankylosing Spondylitis Functional Index: BASFI), spinal mobility (Bath Ankylosing Spondylitis Metrology Index: BASMI), enthesitis score (Maastricht Ankylosing Spondylitis Enthesitis Score: MASES), pain (Visual Analogue Scale: VAS), quality of life (Ankylosing Spondylitis Quality of Life: ASQoL) and depression (Beck Depression Inventory: BDI) of all patients were evaluated. Similar demographic data were found in both groups. Significant differences were acquired between the patient and control groups regarding all postural stability tests ($p<0.05$). The BASDAI, BASMI, BASFI, MASES, VAS pain, modified Schober's test, ASQoL, and BDI were associated with sway velocity on a firm surface with eyes closed. There was a significant correlation between MASES and all tests of sway velocity. Dynamic postural stability in the sagittal plane and whole tests (except on foam surface eyes closed test) of sway velocity were affected negatively in patients with Achilles enthesitis. Static and dynamic postural stability impairments are seen in AS. Enthesitis significantly impaired static postural stability and increased postural sway.

Keywords: Ankylosing spondylitis, enthesitis, postural stability, sensory integration and balance, postural deformity

Introduction

Ankylosing spondylitis (AS) is an axial spondyloarthritis which primarily affects the axial skeleton. Peripheral joints and entheses are frequently affected. It is common among young people, especially in males, who generally present at ages younger than 30 years. AS is characterized by spinal stiffness and loss of spinal mobility, which is explained by spinal inflammation, structural damage or both [1]. As the disease progresses, postural changes become more marked. Chronic structural changes occur with new bone formation and progression to fusion (ankyloses) in the inflamed sacroiliac joints, spinal and peripheral joints, which cause a reduction in the range of motion, mobility, and flexibility [2].

Thoracic kyphotic deformity in patients with AS causes forward and downward displacement of the center of gravity of the body in the sagittal plane [3-5]. A series of compensations, including pelvic retroversion, hip extension, knee flexion, and ankle plantar flexion develop to maintain erect posture and align the head and eyes to a horizontal position [3,5,6]. With the progression of AS, balance is impaired and postural control strategies become inadequate to cope with poor balance. [3-5].

Balance is the capability to maintain the body's center of mass within the base of support with minimal postural sway. Balance is affected by postural changes and the displaced center of gravity. The cooperation of sensory (vestibular, visual, and somatosensory inputs) and musculoskeletal systems maintain postural stability [5]. In patients with AS, the musculoskeletal system is the prominently affected system.

Enthesitis, a central feature of spondyloarthritis, is the inflammation of tendinous or ligamentous insertions onto the bone. Enthesitis most commonly affects the Achilles tendon site and also may affect joint structures in AS [7]. Components in the spine, like ligaments, intervertebral discs, facet joints, interspinous muscles, posterior annulus, and the posterior longitudinal ligament contribute to proprioceptive control [8]. Previous studies have speculated that

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enthesopathy disturbs proprioception by damaging the afferent nerve fibers in ligaments, tendons, and joint capsule system, and this may contribute to balance impairment [5,6,9,10].

In AS, pain, stiffness, fatigue, reduced spinal mobility, and restriction of the respiratory functions have impacts on different aspects of the patient's physical disability [11]. Some studies have shown the relationship between AS and balance and postural parameters, but no information exists regarding the association between enthesitis score and postural stability [3-5,8-10].

In the present study, our first aim was to investigate the static and dynamic postural stability in patients with AS and to disclose their relationships with clinical parameters, postural measurements, enthesitis score, quality of life and depression. The second purpose was to examine the effects of Achilles enthesopathy on static and dynamic postural stability.

Material and Methods

Patient diagnosed with AS with using the 1984 modified New York Classification Criteria [12] and healthy subjects matched for age, sex, and body mass index (BMI) were involved in the study. Hospital employees volunteered as healthy participants. Written informed consent from all participants was obtained before participating, and the study protocol was approved by Medipol University Human Research Ethics Board. This study was conducted in accord with the ethical principles outlined in the Declaration of Helsinki.

The exclusion criteria for both groups were as follows: (1) unwillingness to participate in the study, (2) visual or vestibular disorders, (3) cognitive problems, (4) neurologic disorders that could result in balance problems or lower extremity motor paresis (e.g., multiple sclerosis, cerebrovascular disease, polyneuropathy), (5) active lower extremity arthritis or orthopaedic problems (contracture or range of motion limitations of low extremities, length difference between the legs of more than 1 cm, any surgical history of the lower extremities or vertebrae-related problems, scoliosis) affecting balance and posture, (6) cardiovascular disorders, (7) psychiatric disorders that affected communication, (8) age under 20 years and above 65 years, and (9) pregnancy.

Patients with AS were evaluated in the afternoon to rule out the effects of morning stiffness.

Clinical assessment

The demographic data collection, clinical evaluation, and postural measurements were performed by the second author who was blinded to the postural stability measurements. All participants were evaluated using a form comprising demographic data [age, sex, body mass index (BMI)]. Medication and symptom duration were recorded for patients with AS. A detailed musculoskeletal system examination was performed. The range of joint motion, muscle strength of the lower extremities, and any deformities were investigated. Disease activity was measured using the Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) [13]. The functional status was assessed using the Bath Ankylosing Spondylitis Functional Index (BASFI) [14]. The modified Schober's test (MST), chest expansion (CE), tragus-wall distance (TWD), occiput–wall distance, lumbar lateral flexion, and intermalleolar distance were measured, and the Bath Ankylosing Spondylitis Metrology Index (BASMI) was calculated to assess the mobility of the axial skeleton [15]. The clinical evaluation of enthesitis was performed using the Maastricht Ankylosing Spondylitis Enthesitis Score (MASES) [16]. Pain levels were recorded using a 0-10–cm visual analog scale (VAS). Health-related quality of life was assessed by The Ankylosing Spondylitis Quality of Life (ASQoL) questionnaire [17]. The severity of symptoms of depression was measured by the Beck Depression Inventory (BDI) [18]. Pain evaluation was performed by using the Visual analog scale (VAS). Posture was evaluated using tragus-wall distance, modified Schober's test, and chest expansion.

Postural Stability Assessment

Postural stability tests were assessed using the Biodex Balance System (BBS; Biodex Medical System Inc., Shirley, New York, USA), which evaluates neuromuscular control and somatosensory input objectively. Two static tests and one dynamic postural stability test with different dynamic settings were evaluated. The postural stability test emphasized a patient's ability to maintain their center of gravity and balance on static or dynamic setting platforms [19]. All tests were performed under the supervision of the third author.

1. Static Postural Stability Test:

After entering participants' data, body height and the angle of settings for the right and left foot into the system, this test consists of 3 trials performed while standing on a static platform for 20 s per trial with eyes open. The mean score was calculated from the three trials. Three stability indexes were calculated as follows:

- Anterior-Posterior Stability Index (APSI) assessed variation of the platform displacement for sagittal plane movements expressed in degrees.

- Medial-Lateral Stability Index (MLSI) indicated the variability of the platform position for frontal movements expressed in degrees.

- Overall Stability Index (OSI) reflected the variability of the platform position from the horizontal plane for all movements performed in the test.

2. Dynamic Postural Stability Test

This test consists of 3 trials while standing on a dynamic platform for 20 s per trial with eyes open. The mean score was calculated from the three trials. Following the recommendation of a previous study, level 8 is used as the moderate dynamic setting, and level 4 is used as a high dynamic setting (level 12 is stable, 1 is most dynamic) [3]. Dynamic postural stability was measured according to the APSI, MLSI, and OSI indexes for level 8 and level 4. The test evaluations were performed after 60 seconds' rest for each participant between platform stability of 8 and 4. For postural stability measurements, a higher scores indicates excessive motion, and a lower scores indicates better postural stability.

3. Modified Clinical Test of Sensory Integration and Balance (m-CTSIB)

The m-CTSIB targets sensory integration deficits and assesses the participant's postural sway velocity (°/s) under the following four sensory conditions: standing on a firm surface-eyes open, standing on a firm surface-eyes closed, standing on a foam surface-eyes open, standing on a foam surface-eyes closed. A high sway index results means more unsteadiness. Test results of the patients AS were compared with those of the healthy controls.

Statistical analysis

The Shapiro-Wilk test was used to evaluate the normality of data. Frequency, percentage, mean, median, standard deviation, and minimum and maximum were used for descriptive statistics. Quantitative data were compared between the two groups using Student's t-test for parameters with normal distribution and the Mann–Whitney U test for parameters that were not normally distributed. The relationships among variables were described using Spearman's correlation coefficient. A value of $p < 0.05$ was considered statistically significant. The Statistical Package for the Social Sciences version 23 software (SPSS, Chicago, IL, USA) was used for all statistical analyses.

Results

Sixty-four patients with AS (37 males, 27 females) with a mean age of 41.06±8.89 (range, 22- 65) years who were diagnosed in accord with the modified New York criteria volunteered to participate in this prospective controlled study. Forty-two age, sex, and BMI-matched healthy subjects (23 males, 19 females) with a mean age of 38.45±8.46 (range, 24-55) years without any pathology in the musculoskeletal and nervous system were included. The demographic and clinical characteristics of all participants are presented in Table 1. The demographic features of both groups were similar (p>0.05). Thirty-one percent of the patients with AS used tumor necrosis factor (TNF)-α inhibitors (Table 1).

Table 1. Demographic and clinical characteristics of all participants

	Control group n=42	AS group n=64	P[a]
Male, n (%)	23 (54.8)	37 (57.8)	0.757
Age*, years	38.45±8.46	41.06 ±8.89	0.576
BMI* (kg/m²)	25.54±4.43	26.46±3.93	0.270
Symptom duration, years**	-	10 (1-40)	
BASDAI*	-	3.51±2.24	
BASFI**	-	3.35 (0-9)	
BASMI**	-	3 (0-8)	
MASES**		2 (0-12)	
NSAID (%)	-	42.18	
Sulphasalazine (%)	-	3.12	
NSAID+ Sulphasalazine (%)		6.25	
Etanercept (%)	-	12.5	
Adalimumab (%)	-	23.43	
Infliximab (%)	-	1.56	
Golimumab (%)	-	9.37	
Certalizumab pegol (%)	-	1.56	
ASQoL		5 (0-18)	
BDI		9 (0-50)	

AS: ankylosing spondylitis, BMI: body mass index, n: number of subjects NSAID: non-steroidal anti-inflammatory drug, BASDAI: Bath Ankylosing Spondylitis Disease Activity Index, BASFI: Bath Ankylosing Spondylitis Functional Index, BASMI: Bath Ankylosing Spondylitis Metrology Index, MASES: Maastricht Ankylosing Spondylitis Enthesitis Score * mean±SD (standard deviation), ** median (min-max), [a]Independent samples t-test, p<0.05 was considered statistically significant

The static and dynamic postural stability results of both groups are given in Table 2. There were statistically significant differences between the two groups for static and dynamic (level 8 and level 4) postural stability indexes ($p < 0.05$) (Table2).

Table 2. Postural stability and sway indexes of patients with ankylosing spondylitis and healthy controls

	Control group (n=42)	AS group (n=64)	p*
Postural Stability Tests			
Static setting			
APSI	0.15 (0.10-1.50)	0.30 (0.10-2.30)	0.003
MLSI	0.20 (0.0-0.80)	0.30 (0.0- 2.40)	<0.001
OSI	0.30 (0.10-1.60)	0.60 (0.20-2.60)	<0.001
Moderate dynamic setting (level 8)			
APSI	0.50 (0.2-1.50)	1.0 (0.10-2.80)	<0.001
MLSI	0.60 (0.10-1.10)	0.80 (0.30- 3.00)	<0.001
OSI	0.90 (0.20-1.80)	1.40 (0.40- 4.50)	<0.001
High dynamic setting (level 4)			
APSI	0.60 (0.20-1.90)	1.00 (0.30-3.20)	<0.001
MLSI	0.50 (0.10-1.30)	0.80 (0.20-3.20)	<0.001
OSI	0.80 (0.20-2.40)	1.50 (0.50-3.90)	<0.001
A modified clinical test of sensory integration on balance (m-CTSIB)			
Sway velocity on firm surface, eyes open (°/s)	0.31 (0.12-1.23)	0.38 (0.0-1.57)	0.009
Sway velocity on firm surface, eyes closed (°/s)	0.65 (0.18-1.55))	0.65 (0.30-2.11)	0.018
Sway velocity on foam surface, eyes open (°/s)	0.57 (0.24-1.31)	0.70 (0.11-2.08)	0.008
Sway velocity on foam surface, eyes closed (°/s)	1.86 (1.11-3.58)	2.14 (0.26-3.95)	0.018

APSI: anterior-posterior index, MLSI: medial-lateral index, OSI: overall stability index
n: Number of subjects, AS ankylosing spondylitis
*Mann-Whitney U test was used for statistical analysis.
Data are expressed as median and min-max; p<0.05 was considered statistically significant.

The results of correlation analyses between postural stability tests and postural measurements and clinical parameters are shown in Table 3. Neither symptom duration nor TWD showed significant correlations with postural stability scores (Table 3). There was no static and dynamic postural stability index difference between biologic and non-biologic agents treatment groups of patients with AS. The ASQoL and BDI score were positively correlated with increased postural sway velocity on a firm surface with eyes opened or closed.

Patients with Achilles enthesitis had significantly higher APSI of moderate dynamic setting and increased postural sway velocity of all tests (except on a foam surface eyes closed test) (p<0.05) (Table 4).

Table 3. Correlation analyses (r values) of clinical parameters and postural assessment with postural stability indexes and postural sway in the patient group

	Duration	VAS	BASDAI	BASFI	TWD	MST	CE	BASMI	MASES
Postural Stability Tests									
Static setting									
APSI	-0.029	0.062	0.065	0.098	-0.006	-0.142	-0.060	0.009	0.151
MLSI	-0.035	-0.009	-0.052	0.081	-0.101	-0.092	-0.087	0.012	0.107
OSI	-0.045	0.014	-0.011	0.031	-0.11	-0.130	-0.094	0.019	0.116
Moderate dynamic setting (level 8)									
APSI	-0.108	-0.066	0.046	0.036	0.073	-0.182	-0.231	0.170	0.133
MLSI	-0.117	0.110	0.052	-0.045	0.005	0.048	0.086	0.104	-0.050
OSI	-0.057	-0.007	0.064	-0.013	0.041	-0.180	-0.133	0.219	0.030
High dynamic setting (level 4)									
APSI	-0.138	0.135	0.199	0.018	0.022	-0.085	-0.165	0.172	0.041
MLSI	-0.051	0.209	0.254*	0.088	0.052	-0.048	-0.004	0.146	0.026
OSI	-0.106	0.216	0.259*	0.055	0.094	-0.104	-0.141	0.213	0.041
A modified clinical test of sensory integration on balance (m-CTSIB)									
Sway velocity on firm surface, eyes open (°/s)	-0.112	0.185	0.325**	0.339**	-0.033	-0.085	-0.230	0.045	0.371**
Sway velocity on firm surface, eyes closed (°/s)	0.008	0.311*	0.563**	0.429**	0.054	-0.378**	-0.223**	0.326**	0.346**
Sway velocity on foam surface, eyes open (°/s)	0.123	0.284*	0.243	0.214	-0.024	-0.195	-0.291*	0.269*	0.396**
Sway velocity on foam surface, eyes closed (°/s)	0.036	0.293*	0.310*	0.231	-0.079	-0.079	-0.211	0.182	0.321**

VAS: Visual analogue scale, BASDAI: Bath Ankylosing Spondylitis Disease Activity Index, BASFI: Bath Ankylosing Spondylitis Functional Index, BASMI: Bath Ankylosing Spondylitis Metrology Index, TWD: tragus-wall distance, MST: Modified Schober test, CE: chest expansion, MASES: Maastricht Ankylosing Spondylitis Enthesitis Score, APSI: anterior-posterior index, MLSI: medial-lateral index, OSI: overall stability index. The correlation coefficient r value was given. Spearman correlation *p<0.05, ** p<0.01

Table 4. Postural stability and sway indexes of patients with and without Achilles enthesitis

	Patients with Achilles enthesitis n=18	Patients with no Achilles enthesitis n=46	p*
Postural Stability Tests			
Static setting			
APSI	0.40 (0.10-1.70)	0.20 (0.10-2.30)	0.094
MLSI	0.45 (0.10-2.40)	0.30 (0.0-1.90)	0.161
OSI	0.80 (0.20-2.60)	0.60 (0.20-2.60)	0.110
Moderate dynamic setting (level 8)			
APSI	1.30 (0.60-2.80)	0.95 (0.10-2.70)	0.014
MLSI	0.80 (0.30-3.00)	0.80 (0.40-1.90)	0.851
OSI	1.50 (1.00-4.50)	1.35 (0.40-3.20)	0.123
High dynamic setting (level 4)			
APSI	1.25 (0.40-2.50)	0.95 (0.30-3.20)	0.171
MLSI	0.90 (0.30-2.80)	0.80 (0.20-3.20)	0.198
OSI	1.80 (0.60-3.70)	1.40 (0.50-3.90)	0.125
A modified clinical test of sensory integration on balance (m-CTSIB)			
Sway velocity on firm surface, eyes open (°/s)	0.49 (0.21-1.57)	0.37 (0.0-1.45)	0.006
Sway velocity on firm surface, eyes closed (°/s)	0.98 (0.31-2.11)	0.64 (0.18-1.70)	0.039
Sway velocity on foam surface, eyes open (°/s)	0.87 (0.42-2.84)	0.64 (0.11-1.92)	0.019
Sway velocity on foam surface, eyes closed (°/s)	2.27 (1.33-4.95)	2.09 (0.26-3.72)	0.122

APSI: anterior-posterior index, MLSI: medial-lateral index, OSI: overall stability index
*Mann-Whitney U test was used for statistical analysis. Data are expressed as median and min-max; p<0.05 was considered statistically significant.

Discussion

Balance impairment is a frequent and undertreated manifestation in AS. This study concentrated on the static and dynamic postural stability of patients with AS and their relationships with clinical parameters, postural characteristics, and enthesitis scores. Patients and age-matched healthy controls were assessed in terms of static and dynamic postural stability using device-assisted balance tests.

The static postural stability index of patients with AS was significantly impaired compared with healthy controls in this study but did not correlate with clinical parameters, postural measurements, and enthesitis scores. Another static test used in the present study was m-CTSIB. A significant difference was found between the patient and control groups for measurements of sway velocity on firm and foam surfaces with eyes open or closed as reported in previous studies [4,20-22].

The integration of sensory information from visual, vestibular, and somatosensory systems is essential to improve proper postural control or balance by providing more accurate postural cues [5]. In our study, high enthesitis score, restricted spinal mobility, and chest expansion were associated with increased postural sway on a firm surface with eyes closed. Our results show that patients with AS had proprioceptive deficits when compared with healthy subjects because somatosensory input is the primary sensory input for the eyes closed firm surface condition [4,22].

In the present study, patients with high enthesitis scores, restricted spinal mobility, and chest expansion had more difficulty in maintaining their balance while standing on a foam surface with open eyes. This deterioration in static balance can be explained by displacement of the center of mass in the sagittal plane, which has been previously assessed with advanced thoracic kyphosis, forward head posture, stiffness, and pain [3-5, 8]. Accordingly, the m-CTSIB may be a useful test to assess postural abnormalities and spinal mobility in clinical practice for patients with AS.

High disease activity and poor functional status were associated with an increased postural sway when standing on a firm surface with eyes open or closed. It was reported that high disease activity leads to more structural damage, advanced kyphosis, and poor functional status [2,23]. In many studies, although no relation was reported between disease activity and balance, Vergara et al. argued that disease activity, functional status, and pain might modulate sagittal plane postural control in patients with AS [2,4,9,23]. Chronic low back pain led to increased neuromuscular trunk stiffness and changed postural control [24]. In our study, high levels of pain in patients with AS might contribute to impaired postural control and exaggeration of postural sway of the trunk.

Enthesitis, which means the inflammation of the entheses where tendons or ligaments attached to the bone, affects articular capsule nerve endings and Golgi tendon organs. The excitation of chemosensitive nociceptors in facet joints of vertebra, muscles, and tendons may induce alterations in the sensitivity of the fusimotor-muscle spindle system. That situation may lead to decreased proprioceptive acuity [25]. In the present study, high enthesitis scores (MASES score) correlated with high postural sway of the trunk for all conditions. In patients with AS, Achilles enthesitis may also be prominent in disability of balance. Scholes et al. found impaired single-leg standing balance with eyes closed in males with Achilles tendinopathy on the affected side [26]. In our study, Achilles enthesitis impaired dynamic balance in the sagittal plane and increased postural sway of the trunk for all conditions (except in the foam surface-eyes closed test).

Joint damage and ligamentous injury also lead to loss of proprioception. In previous studies, increased sway velocity was also reported for patients with rheumatoid arthritis and psoriatic arthritis who might have reduced sensation due to joint damage and ligamentous injury [27,28]. As it has been reported that hip, knee, and ankle involvement impaired postural control, joint damage may also play a role in the postural stability impairment observed in patients with AS [10,22].

In previous studies, it was also speculated that because patients with AS demonstrated high postural sway index in the eyes-closed condition, this may suggest possible deficits in the audiovestibular system [29-31]. Beneficial results of rehabilitation training have been observed in spine mobility, disease activity, physical function, posture correction, and on vestibular dysfunction and enthesitis in patients with AS [3,29-32]. Postural stability training with eyes-closed conditions should be added to the AS rehabilitation program. Thus a positive effect on proprioception can be achieved.

We observed that moderate (level 8) and high (level 4) dynamic balance were impaired in patients with AS. In the literature, although different methods have been used to investigate dynamic balance in AS, most found impairment in dynamic postural stability [22,33,34]. In our study, only BASDAI was positively correlated with impaired high dynamic postural stability in the horizontal and frontal plane. Although we found no correlation between dynamic postural stability and postural parameters, increased TWD and restricted CE were found to be associated with difficulty in maintaining a dynamic balance in the AS population [3,22] We may admit that high disease activity negatively affects dynamic balance in AS [10].

The majority of patients with AS experienced the disease-related disability, which leads to poor quality of life and psychological distress symptoms. Many previous studies showed that quality of life was impaired in patients with AS and was correlated with many factors such as BASDAI, BASFI, BASMI, fatigue, stiffness, pain, enthesitis, disease duration, poor sleep, appearance, worries about the future, and medication adverse effects [35-38]. Also, the psychological status had close interaction with the quality of life in patients with AS [38]. According to our study, patients with poor quality of life and high depression scores had increased postural sway indices of standing on a firm surface with eyes open or closed.

This study has some limitations. First, abnormal audiovestibular symptoms in patients with AS were reported due to an intra-labyrinthic autoimmune process or ischemia, but no audiovestibular or oculovestibular tests on our patients were performed [29-31]. The impaired static balance in this study may be due to audiovestibular or oculovestibular symptoms. Second, patients with enthesitis in bilateral Achilles tendons or the plantar aponeurosis might have worse postural stability. Further studies are required to investigate this subject with more patients. Third, it has been reported that an increased sway velocity is a predictor of increased risk of falls; fall risk was not assessed in this study [10].

Conclusion

This study showed that static and dynamic postural stability and sensory integration in balance were significantly altered in patients with AS. Dynamic balance was affected by disease activity and Achilles enthesitis, and sensory integration was affected by clinical parameters, postural measurements, and enthesitis. The MASES score was correlated with all conditions of sensory integration test and Achilles enthesitis significantly increased postural sway. Enthesopathy is an important entity for postural control in the AS population. Static postural stability with increased postural sway was the most influenced component with the progression of AS. As a result; balance assessment may be performed for patients with AS, albeit an early stage. Therefore, a more specific rehabilitation program in which postural and specific proprioceptive exercises are added should be given to improving balance in various conditions. As with the BATH indexes of AS, a risk assessment tool that assesses patients' postural stability should be generated.

Conflict of interest
The authors report no conflict of interest.

Financial Disclosure
The authors declared that this study had received no financial support.

Ethical approval
The study protocol was approved by Medipol University Human Research Ethics Board. Ethics number:10840098-604.01.01-E45120.

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References

1. Sieper J, Poddubnyy D. Axial spondyloarthritis. Lancet. 2017;390:73-84.
2. Harper BE, Reveille JD. Spondyloarthritis: clinical suspicion, diagnosis, and sports. Curr Sports Med Rep. 2009;8:29-34.
3. Aydog E, Depedibi R, Bal A, et al. Dynamic postural balance in ankylosing spondylitis patients. Rheumatology. 2006;45:445-8.
4. Murray HC, Elliott C, Barton SE, et al. Do patients with ankylosing spondylitis have poorer balance than normal subjects? Rheumatology. 2000;39:497-500.
5. Bot SD, Caspers M, Van Royen BJ, et al. Biomechanical analysis of posture in patients with spinal kyphosis due to ankylosing spondylitis: a pilot study. Rheumatology. 1999;38:441-3.
6. Debarge R, Demey G, Roussouly P. Radiological analysis of ankylosing spondylitis patients with severe kyphosis before and after pedicle subtraction osteotomy. Eur Spine J 2010;19:65-70.
7. D'Agostino MA, Olivieri I. Enthesitis. Best Pract Res Clin Rheumatol. 2006; 20:473-86.
8. De Nunzio AM, Iervolino S, Zincarelli C et al. Ankylosing spondylitis and posture control: the role of visual input. Biomed Res Int. 2015;2015:948674.
9. Swinkels A, Dolan P. Spinal position sense and disease progression in ankylosing spondylitis: a longitudinal study. Spine (Phila Pa 1976) 2004;29:1240-5.
10. Dursun N, Sarıkaya S, Ozdolap S et al. Risk of falls in patients with ankylosing spondylitis. J Clin Rheumatol. 2015;21:76-80.
11. Vergara ME, O'Shea FD, Inman RD et al. Postural control is altered in patients with ankylosing spondylitis. Clin Biomech. 2012;27:334-40.
12. Van der Linden S, Valkenburg HA, Cats A. Evaluation of diagnostic criteria for ankylosing spondylitis. A proposal for modification of the New York criteria. Arthritis Rheum. 1984;27:361-8.
13. Akkoc Y, Karatepe AG, Akar S, et al. A Turkish version of the bath ankylosing spondylitis disease activity index: reliability and validity. Rheumatol Int. 2005;25:280-4.
14. Karatepe AG, Akkoc Y, Akar S, et al. The Turkish versions of the Bath Ankylosing Spondylitis and Dougados Functional Indices: reliability and validity. Rheumatol Int. 2005;25:612-8.
15. Jenkinson TR, Mallorie PA, Whitelock HC, et al. Defining spinal mobility in ankylosing spondylitis (AS). The Bath AS Metrology Index. J Rheumatol. 1994;21:1694-8.
16. Heuft-Dorenbosch L, Spoorenberg A, van Tubergen A, et al. Assessment of enthesitis in ankylosing spondylitis. Ann Rheum Dis. 2003;62:127-32.
17. Duruöz MT, Doward L, Turan Y et al. Translation and validation of the Turkish version of the Ankylosing Spondylitis Quality of Life (ASQOL) questionnaire. Rheumatol Int. 2013;33:2717-22.
18. Beck AT, Ward CH, Mendelson M, et al. An inventory for measuring depression. Arch Gen Psychiatry. 1961;4:561-71.
19. Arnold BL, Schmitz RJ. Examination of balance measures produced by the biodex stability system. J Athl Train. 1998;33:323-7.
20. Batur EB, Karataş GK. Do postural changes affect balance in patients with ankylosing spondylitis? J Rehabil Med 2017;49:437-40.
21. Sawacha Z, Carraro E, Del Din S, et al. Biomechanical assessment of balance and posture in subjects with ankylosing spondyli¬tis. J Neuroeng Rehabil. 2012;9:63.
22. Gunduz OH, Ozcan-Eksi EE, Giray E, et al. What impairs balance in ankylosing spondylitis? Posture or disease activity? Arch Rheumatol. 2017;32:221-6.
23. Ramiro S, van der Heijde D, van Tubergen A, et al. Higher disease activity leads to more structural damage in the spine in ankylosing spondylitis: 12-year longitudinal data from the OASIS cohort. Ann Rheum Dis. 2014;73:1455-61.
24. Lafond D, Champagne A, Descarreaux M, et al. Postural control during prolonged standing in persons with chronic low back pain. Gait & Posture 2009;29:421-7.
25. Demontis A, Trainito S, Del Felice A, et al. Favorable effect of rehabilitation on balance in ankylosing spondylitis: a quasi-randomized controlled clinical trial. Rheumatol Int. 2016;36:333-9.
26. Scholes M, Stadler S, Connell D, et al. Men with unilateral Achilles tendinopathy have impaired balance on the symptomatic side. J Sci Med Sport. 2018;21:479-82.
27. Rome K, Dixon J, Gray M, et al. Evaluation of static and dynamic postural stability in established rheumatoid arthritis: exploratory study. Clin Biomech. 2009;24:524-6.
28. Duruoz MT, Baklacioglu HS, Sanal Toprak C, et al. The evaluation of the static and dynamic balance disorders in patients with psoriatic arthritis. Rheumatol Int. 2018;38:2063-8.
29. Adam M, Erkan AN, Arslan D, et al. High-frequency sensorineural hearing loss in patients with ankylosing spondylitis: Is it an extraarticular feature of disease? Rheumatol Int. 2008;28:413-7.
30. Amor-Dorado JC, Barreira-Fernandez MP, Vazquez-Rodriguez TR, et al. Audiovestibular manifestations in patients with ankylosing spondylitis. Medicine (Baltimore). 2011;90:99–109.
31. Erbek SS, Erbek S, Yilmaz S, et al. Cochleovestibular dysfunction in

ankylosing spondylitis. Audiol Neurootol. 2006;11:294-300.

32. Martins NA, Furtado GE, Campos MJ, et al. Exercise and ankylosing spondylitis with New York modified criteria: a systematic review of controlled trials with meta-analysis. Acta Reumatol Port. 2014;39:298-308.

33. Çınar E, Akkoç Y, Karapolat H, et al. Postural deformities: potential morbidities to cause balance problems in patients with ankylosing spondylitis? Eur J Rheumatol. 2016;3:5-9.

34. Durmus B, Altay Z, Ersoy Y, et al. Postural stability in patients with ankylosing spondylitis. Disabil Rehabil. 2010;32:1156-62.

35. Ward MM. Health-related quality of life in ankylosing spondylitis: a survey of 175 patients. Arthritis Care Res. 1999;12:247-55.

36. Bodur H, Ataman S, Rezvani A, et al. Quality of life and related variables in patients with ankylosing spondylitis. Qual Life Res. 2011;20:543-9.

37. Maksymowych WP, Mallon C, Morrow S, et al. Development and validation of the spondyloarthritis research consortium of Canada (SPARCC) Enthesitis Index. Ann Rheum Dis. 2009;68:948-53.

38. Baysal O, Durmus B, Ersoy Y, et al. Relationship between psychological status and disease activity and quality of life in ankylosing spondylitis. Rheumatol Int. 2010;31:795-800.