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Evaluation of balance disorder and associated factors in patients with ankylosing spondylitis

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ABSTRACT

Objective: The aim of this study was to investigate balance disorder and the factors associated with it in patients with ankylosing spondylitis (AS).

Patients and Methods: The study included 75 patients diagnosed with AS and 75 healthy volunteers. Patients and controls were analysed for demographic characteristics, and AS patients were also investigated for disease activity indices and disease duration. Patient and control groups were compared using static and dynamic balance tests.

Results: The scores of AS patients were found to be worse than the control group (p=0.000) in terms of Static Double-Feet Balance Index (SDFBI), Static Single-Feet Balance Index (SSFBI), Dynamic Balance Index (DBI), Timed Up and Go test (TUGT), Berg Balance Scale (BBS), Functional Reach Test (FRT) and Hand to Ground Distance (HGD). Balance impairment was significantly higher in patients with kyphosis and advanced stage of sacroiliitis. Kyphosis angle, stage of sacroiliitis, Bath Ankylosing Spondylitis Metrology Index (BASMI), OWD (occiput-to-wall distance) scores, presence of contracture in hip or knee joint and Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) were correlated with poor balance when evaluated with balance evaluation scales for correlation.

Conclusions: Balance was impaired in AS patients. Appropriate treatment and rehabilitation protocols for spinal and peripheric joint stiffness may improve balance disorder in AS patients.

Keywords: Ankylosing spondylitis, Posture, Balance

1. INTRODUCTION

Ankylosing spondylitis (AS) is a chronic inflammatory disease affecting the axial skeleton, leading to inflammation in spinal joints and adjacent structures and progressive bone fusion in vertebra [1]. The fusions in vertebrae cause spinal mobility limitations and difficulties in daily living activities [2]. The changes in the vertebral structure become more evident as the disease progresses, and the vertebrae can turn into rigid bone bundles from occiput to sacrum, and even rigid thoracolumbar kyphotic deformity may occur [3]. Kyphotic deformity may cause the body's center of gravity to shift forward, making it difficult to perform daily living activities such as interpersonal communication, driving, walking, and personal hygiene [4, 5]. The characteristic posture of AS includes ventral flexion of the head and neck, increased thoracic kyphosis, and tightness of the hip and knee flexors [6]. It was reported that postural disorder leads to the impairment of balance and increased risk of falling [5]. Khan et al., reported that patients with AS may injure themselves more easily after sudden position changes due to spinal stiffness that impairs the ability to maintain balance [1, 6]. Although, postural alterations are considered to affect balance, the studies investigating balance problems in patients with AS have controversial findings. The number of studies investigating balance problems in AS and relevant factors are limited. While, some studies report that postural alterations have no effects on the balance of AS patients [7-10], others claim balance is impaired, and falling risk is increased [11-15]. Impairment of balance was linked to kyphosis [11,12,16,17], limitations in spinal mobility, advanced postural alterations [11-15], loss of

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proprioception [9,12,13,18], and disease activity [15] in the studies.

Investigations of the effect of ankylosing spondylitis on balance can illuminate the possible mechanism of fall risk in patients and emphasize balance training as part of treatment. This study aimed to investigate the effects of postural alterations on balance using the clinical balance assessment tools and the static and dynamic balance index.

2. PATIENTS and METHODS

Seventy-five patients diagnosed with AS according to the modified New York Criteria, and 75 healthy volunteers were included in the study. The study was approved by the Selcuk University, Faculty of Medicine, Non-interventional Ethics Committee (date. 28.04.2025, approval number: 2015/148), and the study was conducted in accordance with the Declaration of Helsinki for human and animal rights. Patients with neurological and/or metabolic diseases that cause balance disorder, those with orthopedic disorders that affect balance and spinal mobility, and those with a history of chronic alcohol use and taking medication that can lead to balance disorder, pregnants, malign disorders and under 18 and over 60 years of age were excluded from the study. All participants were informed about the design and aim of the study, and a consent form was obtained from all participants before the study.

The demographic features of all participants, such as date of age, gender, weight, height, body mass index (BMI), marital status, education level, occupational status, family structure, monthly income level, and duration of AS for the patient group were determined. Joint and extra-articular involvement were also evaluated in the AS group. For the AS group, the pain level and disease activity were assessed with the visual analog scale (VAS) of 0-10 cm and BASDAI, respectively. BASDAI is an index used to determine disease activity and evaluate the parameters, such as fatigue, spinal pain, peripheral arthritis, enthesitis, and severity and duration of morning stiffness [19]. The presence of contracture of hip and knee joints was recorded. All participants were assessed in the afternoon to avoid the effects of morning stiffness. The patients were asked not to take non-steroid anti-inflammatory drugs or exercise within 24 hours before evaluation to prevent changing BASDAI, BASMI, and VAS scores. Occiput-to-wall distance (OWD), tragus-wall distance, modified Schober, lumbar lateral flexion, cervical rotation, chest expansion, kyphosis angle, and BASMI measurements were compared between groups and in the AS group. BASMI includes five clinical measurements that reflect axial mobility to evaluate spinal mobility [20]. The AS patients were also classified according to the presence/absence of kyphosis, stage of sacroiliitis, and BASDAI. A physical medicine and rehabilitation specialist did the physical examination and took the spinal measurements.

All participants were compared in terms of the Static Double-Feet Balance Index (SDFBI), Static Single-Feet Balance Index (SSFBI), DBI, dynamic fall risk (DFR), static fall risk (SFR), Berg Balance Scale (BBS), Timed Up and Go test (TUGT), Functional Reach Test (FRT), and SportKAT 4000® (LLC-Vista, California, USA) device scores.

Berg Balance Scale is composed of 56 points, and a score of 45 or more is accepted as a good balance. Higher scores in BBS indicate better balance [21,22]. It was seen that people who completed TUGT in less than 20 sec had higher scores in BBS and had a normal gait speed (0.5 m/sec), which is necessary for walking in the community. However, it was observed that those who had completed TUGT at 30 sec or more were more dependent on daily living activities, needed assisted devices for ambulation, and got lower scores in BBS [23,24]. The reliability and validity of the Turkish version of BBS were made by Sahin et al. [25].

For FRT, the patients were asked to lift the upper limbs so that the shoulders were at 90° flexion and reached the furthest distance that could be reached without stepping and touching the wall. The measurements were repeated three times for each patient, and an average score was recorded [26,27].

Both static and dynamic balance measurements were performed with a SportKAT 4000® device (LLC-Vista, California, USA). The SportKAT 4000® is a platform moveable up to 20° and supported by a small pivot at the center point. The fixation of the platform is achieved by changing the pressure of the round pneumatic mechanism between the lower part of the unit and the platform. The inclined sensor in front of the platform is connected to a computer, recording the deviation of the platform. Patients stand up and try to move the platform as desired with the motion of the center of body weight. While doing this, they can follow their movements on the computer monitor located at eye level. During the test, the distance between the center point and reference position is calculated for each recording. The reference position may be a fixed point or a moveable cursor. Therefore, a score balance index (BI) is calculated by summing up the measurements of these distances. BI measures the individual's ability to hold the platform close to the reference position. On the device, the static mode evaluates static balance by asking the patient to keep the X symbol (center of body weight) at the center of the screen. Dynamic mode evaluates dynamic balance by asking the patient to move the platform in a way that follows a cursor or a pattern on the screen. The interval between the lowest and highest scores ranges from 0 to 6000. Lower scores indicate better balance. The scores are indirect identifiers of balance. Scores of 750 or more on SDFBI and SSFBI and 2000 or more on DBI are associated with an increased risk of falling. In our study, all tests were performed for 30 seconds after sufficiently training all patients and when pneumatic ground pressure was 6 (psi). For SSFBI, the test was evaluated on the dominant foot [28].

The Cobb angle was used to calculate thoracic kyphosis. The angle at the intersections of vertical lines arising from each of the parallel lines drawn from the upper edge of T3 and the lower edge of T12 was calculated as the thoracic kyphosis angle, and the value over 40° was evaluated as kyphotic deformity [29]. Radiographic sacroiliitis was assessed according to the modified New York criteria and graded between 0-4 [27].

Statistical Analysis

Statistical analysis was performed using SPSS 21.0 (IBM Corp, Armonk, NY, USA). The Kolmogorov-Smirnov test checked whether the numerical variables were appropriate for normal distribution. The parametric and non-parametric data of the patients were compared with the student's t-test and chi-square test, respectively. The Mann-Whitney U and Kruskal Wallis tests were used to analyze the inappropriate distributions of the data. In determining the correlations between variables, Pearson's correlation analysis was used when parametric conditions were provided; otherwise, Spearman's correlation analysis was applied. A p <0.05 was accepted as a statistical significance level.

3. RESULTS

The demographic features of the patient and control group were similar in terms of age, height, weight, BMI, and gender (p>0.05) (Table I). When the patient and control groups were compared regarding SDFBI, SSFBI, DBI, BBS, TUGT, and FRT, all tests showed significant differences in favor of balance disorder for AS patients (Table II). When AS patients were divided according to the presence of kyphosis, a significant difference was found in SDFBI, SSFBI, DBI, BBS, and TUGT scores in patients with kyphosis. There was no significant difference between FRT scores (Table III). When AS patients were classified into three groups according to the stage of sacroiliitis, significant differences were found in SDFBI, SSFBI, DBI, TUGT scores, and kyphosis angle. There was no difference in BBS and FRT scores (Table IV).

Table I. *Sociodemographic and clinical features of patient and control group (with mean±SD)*

	Patients with AS (n=75)	Controls (n=75)	P
Age (years)	36.56±10.32	33.71±8.16	.062
Height (cm)	168.63±8.85	170.96±9.19	.115
Weight (kg)	70.97±14.46	71.68±11.52	.741
BMI (kg/cm²)	24.90±4.40	24.54±3.69	.593
Gender			
Female	24 (32%)	25 (33.3%)	.862
Male	51 (68%)	50 (66.7%)	
Duration of disease (years)	7.71±6.83	-	
BASFI	3.50±2.73	-	
BASDAI	4.49±2.08	-	
BASMI	2.80±2.70	-	

AS: *Ankylosing Spondylitis,* ***BASMI:*** *Bath Ankylosing Spondylitis Metrology Index,* ***BASDAI:*** *Bath Ankylosing Spondylitis Disease Activity Index,* ***BASFI:*** *Bath Ankylosing Spondylitis Functional Index,* ***BMI:*** *Body mass index*

Correlation analysis revealed that kyphosis angle was moderately positively correlated with SDFBI (p<0.001, r=0.393), SSFBI (p=0.002,r= 0.345), DBI (p=0.008, r=0.304) and TUGT scores (p=0.001, r= 0.544) and moderate negatively with BBS (p=0.001, r=-0.522). Stage of sacroilitis was moderate positively correlated with SDFBI (p=0.001, r=0.387), SSFBI (p=0.001, r= 0.370), DBI (p=0.019, r=,0.270) and TUGT scores (p=0.00, r= 0.436) and weak negatively with BBS (p=0.025, r=-0.258). BASMI scores were moderate positively correlated with SDFBI (p=0.000, r=0.444), SSFBI (p=0.009, r= 0.301), DBI (p=0.009, r=,0.299) and TUGT scores (p=0.001, r= 0.732) and moderate negatively with BBS (rp=0.001, r=-0.692). OWD scores was moderate positively correlated with SDFBI (p=0.001, r=0.371), SSFBI (p=0.003, r= 0.341) and TUGT scores (p=0.000, r= 0.669), weak positively correlated with DBI (p=0.013, r=,0.286) and moderate negatively with BBS (p=0.001, r=-0.575). Presence of contracture was weak positively correlated with SDFBI (p=0.031, r=0.249), SSFBI (p=0.018, r= 0.273), moderate positively correlated with DBI (p=0.004, r=0.327) and TUGT scores(p=0.001, r=0.403) and moderate negatively with BBS (p=0.000, r=-0.486).

Also, there was a moderate positive correlation between BASDAI and SDFBI (p=0.001, r=0.363) and DBI (p=0.005, r=0.320) and a moderate negative correlation between BASDAI and BBS scores(p0.001, r=-427) (Table V).

Table II. *Balance test scores in ankylosing spondylitis patients and control group with mean±SD*

	Patients with Ankylosing Spondylitis (n=75)	Controls (n=75)	P
HGD	14.07±11.90	3.15±4.79	<0.000
FRT	25.53±8.07	32.2±4.26	<0.000
BBS	53.67±3.54	56±0.00	<0.000
TUGT	10.95±2.70	9.01±0.12	<0.000
SDFBI	359.47±95.90	218.23±44.75	<0.000
SSFBI	405.87±117.37	225.12±53.94	<0.000
DBI	2476.31±542.84	2615.00±305.43	<0.0010

SDFBI: *Static Double-Feet Balance Index,* ***SSFBI:*** *Static Single-Feet Balance Index,* ***DBI:*** *Dynamic Balance Index,* ***TUGT:*** *Timed Up and Go test,* ***BBS:*** *Berg Balance Scale,* ***FRT:*** *Functional Reach Test,* ***HGD:*** *Hand to Ground Distance*

Table III. *Balance scores in ankylosing patients with and without kyphosis with mean±SD*

	With Kyphosis (n=45)	Without Kyphosis (n=30)	P
SDFBI	387.22±96.57	317.83±79.54	0.003
SSFBI	445.29±114.96	346.73±95.26	0.001
DBI	2602.78±529.77	2286.60±513.85	0.007
TUGT	11.78±3.14	9.70±10.01	<0.0010
BBS	52.69±4.16	55.10±1.64	0.002
FRT	24.28±9.03	27.04±6.05	0.139
BASMI	3.71±3.00	1.43+1.33	0.001

SDFBI: *Static Double-Feet Balance Index,* ***SSFBI:*** *Static Single-Feet Balance Index,* ***DBI:*** *Dynamic Balance Index,* ***TUGT:*** *Timed Up and Go test,* ***BBS:*** *Berg Balance Scale,* ***FRT:*** *Functional Reach Test,* ***BASMI:*** *Bath Ankylosing Spondylitis Metrology Index*

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Table IV. *Association between radiographic sacroiliitis stage and balance tests with mean±SD*

	Stage 2 (n=13)	Stage 3 (n=22)	Stage 4 (n=40)	p
SDFBI	311.31±59.22	319.23±75.66	397.25±100.68	0.001
SSFBI	343.85±69.47	369.40±118.26	446.07±115.91	0.004
DBI	2104.38±318.31	2527.59±607.87	2568.97±522.09	0.019
Angle of kyphosis	34.01±8.11	40.53±11.73	48.52±11.83	<0.001
BBS	55.23±1.42	54.45±2.02	52.70±4.39	0.088
TUGT	9.42±0.76	10.48±2.41	11.7±3.01	0.001
FRT	28.50±7.26	26.95±6.91	23.56±8.47	0.112
BASMI	0.83±1.11	1.68±1.32	4.05±2.99	<0.001

SDFBI: *Static Double-Feet Balance Index,* ***SSFBI:*** *Static Single-Feet Balance Index,* ***DBI:*** *Dynamic Balance Index,* ***TUGT:*** *Timed Up and Go Test,* ***BBS:*** *Berg Balance Scale,* ***FRT:*** *Functional Reach Test,* ***BASMI:*** *Bath Ankylosing Spondylitis Metrology Index*

Table V. *Correlation of measurement parameters with balance tests*

	SDFBI	SSFBI	DBI	TUGT	BBS
Angle of kyphosis					
r	.393**	.345**	.304**	.544**	-.522**
p	<0.001	.002	.008	<0.001	<0.001
Stage of sacroiliitis					
r	.394**	.364**	.278*	.326**	-.290*
p	.001	.001	.019	<0.001	.025
BASMI					
r	.444**	.301**	.299**	.732**	-.692**
p	<0.001	.009	.009	<0.001	<0.001
BASDAI					
r	.363**	.092	.320**	-.427**	.222
p	.001	.494	.005	<0.001	.055
OWD					
r	.371**	.341**	.286*	.669**	-.575**
p	.001	.003	0.013	<0.001	<0.001
Contracture in hip or knee joint	.249*	.273*	.327**	-.486**	.403**
r	.031	.018	.004	.000	.000
p					

**. Correlation is significant at the 0.01 level (2-tailed). *.Correlation is significant at the 0.05 level (2-tailed).

SDFBI: *Static Double-Feet Balance Index,* ***SSFBI:*** *Static Single-Feet Balance Index,* ***DBI:*** *Dynamic Balance Index,* ***TUGT:*** *Timed Up and Go Test,* ***BBS:*** *Berg Balance Scale,* ***FRT:*** *Functional Reach Test,* ***BASMI:*** *Bath Ankylosing Spondylitis Metrology Index* ***BASDAI:*** *Bath Ankylosing Spondylitis Disease Activity Index,* ***OWD****:Occiput-Wall Distance*

4. DISCUSSION

In this study, we searched balance disorders in patients with AS and compared the findings with the control group. Also, the association of balance with kyphosis and the stage of sacroiliitis was investigated. In the study, balance impairment was significantly higher in patients with kyphosis and those in the advanced stage of sacroiliitis. Kyphosis angle, stage of sacroiliitis, BASMI, OWD scores, contracture in hip or knee joint, and BASDAI were correlated with poor balance. In a recent study, Cinar et al., reported that balance was disrupted in AS patients compared to healthy individuals, and the severity of balance disorder was correlated with BASMI score [12]. He also emphasized that dynamic balance could be affected more in patients with advanced spinal limitations, and in another study conducted using the Biodex Balance System, reported that the falling risk index scores increased in AS patients compared to the controls [7]. We found that balance was impaired in AS patients compared to the healthy controls, therefore, our findings are consistent with those of these studies.

Durmus et al., found late-stage postural changes, especially in kyphosis, diminished postural stability and in balance in AS patients [10]. Similarly, Batur et al., reported that increased kyphosis causes balance disorder due to the failure of anteroposterior stabilization [13]. Our study showed that SDFBI, SSFBI, DBI, BBS, and TUGT scores significantly differed in AS patients with kyphosis, indicating worse balance scores. Gunduz et al., observed that AS patients who had advanced kyphosis and limitations of spinal mobility limitations had difficulty in providing static and dynamic balance [11]. These results suggest that kyphosis may have an important role on balance in AS patients. So, preventing spinal stiffness and kyphosis or treatments focusing on kyphosis may be beneficial for balance disorder in AS patients.

In the literature, we encountered no studies investigating the association between the stage of sacroiliitis and balance problems in AS patients. In our research, the stage of sacroiliitis was moderately correlated with SDFBI, SSFBI, DBI, and TUGT scores, and there was a negative correlation between the stage of sacroiliitis and BBS. These findings suggest that balance disorder may be associated with the stage of sacroiliitis.

In our study, there was a positive correlation between BASDAI and SDFBI or DBI scores and a negative correlation between BASDAI and BBS scores, suggesting that disease activity has undesirable effects on balance. This finding is consistent with the study of Vergara et al. [16]. Hence, control of disease activity with meticulous medical treatment could improve balance in AS patients and reduce falling risk.

Occiput-to-wall distance scores were positively correlated with SDFBI, SSFBI, DBI, and TUGT scores and negatively correlated with BBS. In a similar study, Batur et al., reported that OWD was associated with balance disorder [13]. As a sign of postural impairment, OWD may be an indicator of balance disorders in AS patients. The presence of contracture of the hip or knee joint was correlated with poor balance, as may be expected, but we did not meet data about contracture and balance relation in AS patients in the literature.

The most important limitation of our study is using clinical balance assessment tests developed for neurologic and geriatric patients. There is no balance assessment tool specific to AS. However, the sample size and different balance assessment tools may be considered powerful aspects of the study.

According to the literature, progression of spinal and peripheric joint involvement and disease activity were correlated with poor

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balance in AS patients. So, prevention of disease progression and control of disease activity play an important role in balance. Management of balance disorder is crucial for these patients. Appropriate treatment and rehabilitation protocols for spinal and peripheric joint stiffness may improve balance disorder and daily living activities by restoring mobility and preventing balance-associated injuries [18,30]. Further studies, including larger populations, are required. Also, developing specific balance assessment tools for AS will provide a more favorable evaluation of balance disorder.

Compliance with Ethical Standards

Ethics committee approval: The study was approved by the Selcuk University, Faculty of Medicine, Non-interventional Ethics Committee (date: 28.04.2015, approval number: 2015/148), and the study was conducted in accordance with the Declaration of Helsinki for human and animal rights. All participants were informed about the design and aim of the study, and a consent form was obtained from all participants before the study.

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Authors contributions: AAI: Conception, design, materials, literature review, writer, data collection, analysis/interpretation, HY: Design, crtical review, literature review, analysis/interpretation, supervision, HG: Literature review, writer, critical review, supervision. All authors approved the final version of the article.

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