Erciyes Med J 2023; 45(1): 79–83 • DOI: 10.14744/etd.2022.16363
ORIGINAL ARTICLE – OPEN ACCESS

Static Postural Control Data Analysis in Patients with Ankylosing Spondylitis

Menekşe Karahan[1], Muhammed Parlak[2], Ayşe Zeynep Yılmazer Kayatekin[3], Enis Uluçam[4], Nurettin Taştekin[5]

ABSTRACT

Objective: The goal of our study was to determine how ankylosing spondylitis, a chronic inflammatory disease, affected patient's balance.

Materials and Methods: Thirty-one healthy volunteers and thirty-five patients with ankylosing spondylitis and no comorbidities affecting their balance participated in the study. Bipedal balance analysis was performed with the subjects' eyes open and closed in each group. The position of the center of pressure during the measurement was evaluated.

Results: The mediolateral deviation of the center of pressure (p=0.035) and the total path length (p=0.042) were significantly higher in the patient group when measured with eyes open. PL was significantly longer in the patient group when measured with eyes closed (p=0.002).

Conclusion: We observed that ankylosing spondylitis negatively affected the balance in patients. Since this disease usually occurs in the young population, it should be taken into consideration that balance impairment can complicate daily life, especially in the professional world. Therefore, it can be useful to consider the balance disorder in the treatment, and the patients should be monitored for an extended period.

Keywords: Ankylosing spondylitis, balance analysis, bipedal balance, center of pressure, postural control

Cite this article as: Karahan M, Parlak M, Yılmazer Kayatekin AZ, Uluçam E, Taştekin N. Static Postural Control Data Analysis in Patients with Ankylosing Spondylitis. Erciyes Med J 2023; 45(1): 79-83.

Manuscript that have been presented as oral presentation 'Correlation of static postural control data of patients with ankylosing spondylitis and healthy subjects', 19th National Anatomy Congress, Konya, Türkiye, 6-9 September 2018, O-77

[1]Department of Anatomy, Kırklareli University Faculty of Medicine, Kırklareli, Türkiye
[2]Department of Anatomy, Bezmialem Vakıf University Faculty of Medicine, İstanbul, Türkiye
[3]Department of Anatomy, Tekirdağ Namık Kemal University Faculty of Medicine, Tekirdağ, Türkiye
[4]Department of Anatomy, Trakya University Faculty of Medicine, Edirne, Türkiye
[5]Department of Physical Medicine and Rehabilitation, Trakya University Faculty of Medicine, Edirne, Türkiye

Submitted 14.12.2021

Revised 04.02.2022

Accepted 28.09.2022

Available Online 29.12.2022

Correspondence Menekşe Karahan, Kırklareli University Faculty of Medicine, Department of Anatomy, Kırklareli, Türkiye
Phone: +90 288 214 95 15
e-mail: karahanmenekse@hotmail.com

INTRODUCTION

Ankylosing spondylitis (AS), which is associated with mankind since ancient times as indicated by a number of research on Egyptian mummies, is a chronic inflammatory disease (1). Its incidence rate in the population ranges from 0.1% to 1.4% (2). The sacroiliac joints, the spine, and, to a lesser extent, the peripheral joints are most commonly affected by AS (3). It results in vertebral deformities and progressive loss in the range of motion (3). It is also the most common form of spondyloarthropathy (4). Although the onset of AS symptoms usually happens in the late adolescence and beginning of adulthood, the symptoms can also be seen in childhood. The average age of diagnosis of AS is 24 years (4, 5).

As the disease progresses, the patient's posture worsens (6). The affected spine stiffens from the occiput to the sacrum, resulting in an immobile kyphosis posture, particularly in the thoracic vertebrae (6, 7). This condition is caused by sacroiliitis, inflammation, and consolidation of the articular surface. The most important clinical feature of the disease is the distorted posture of the spine (8). It is believed that patients with poor posture may have balance problems (9). The patient's head and face can tilt downward as a result of advanced thoracolumbar kyphosis (10). The center of mass (COM) is shifted forward and downward in the sagittal plane as a result of this posture (7). When other parts of the body are stationary, the COM remains in front of the support area. In order to avoid this, patients develop compensatory mechanisms (11). Posture changes such as decreased lumbar lordosis, pelvic anteversion, knee flexion, hip flexion, and ankle dorsiflexion are expected in these patients (6).

Balance is controlled by mechanisms such as central processing of sensation and subsequent neuromuscular response. Sensory elements include the ocular, proprioceptive, and vestibular systems (12). An effective motor response is possible with a healthy nervous and muscular system. Balance control is required in static and dynamic situations (9). Balance problems may occur in patients with AS as a result of severe joint deformities and poor body posture (7). These patients have an increased risk of falling (7). Aside from the psychosocial impacts of the disease, fall-related injuries may also exacerbate the situation. Furthermore, adverse socioeconomic conditions emerge since the patients are young who are actively contributing to the workforce (13).

It is known that AS negatively affects physical activity and hampers the quality of life of patients (14). Good postural control is also very important for the successful performance of daily activities (15). The goal of our study was to investigate how AS affected postural control.

MATERIALS and METHODS

Study Design

This cross-sectional study was conducted in 2017 in Trakya University Hospital (Edirne, Türkiye). The sample size was calculated as 30 participants for each group using the G*power 3.1.9.7 (RRID:SCR_013726) program before initiating the study (effect size, 0.8; alpha, 0.05; and power, 0.85). The effect size was calculated in accordance with the literature (16). The study was conducted with 35 patients and 31 healthy volunteers.

The Ethics Committee of the Faculty of Medicine, Trakya University approved our study after it was structured in compliance with the criteria of the Declaration of Helsinki (decision date: April 27, 2016, decision number: 08.04). Before starting the study, each participant signed an consent form.

Patient and Data Collection

Thirty-one healthy volunteers and thirty-five patients with AS who were under the care of the outpatient service of the Physical Medicine and Rehabilitation clinic of the Faculty of Medicine, Trakya University were enrolled in the study. Patients with diseases other than AS (orthopedic, neurological, or vestibular disease) or on medications that could cause vestibular disorders were excluded from the study. The patients' Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) scores were calculated. The BASDAI is a method wherein patients score their intensity of symptoms such as pain, stiffness, and fatigue (17). Since a score of ≥4 indicates the high severity of the disease and the need for reconsideration of its treatment, patients with a score of ≤4 were included in the study. The disease was diagnosed based on the Modified New York criteria (18).

The balance analysis was performed in the motion analysis laboratory of the Faculty of Medicine, Department of Anatomy, Trakya University. A force platform (Zebris, FDM System Type 3.5) was used for the analysis. The force platform was 158-cm long, 60.5-cm wide, and 2.5-cm high. The sensor area of platform was 149-cm long and 54.2-cm wide. The platform had 11,264 sensors, and the measurement width ranged from 1 to 120 N/cm^2. WinFDM (Zebris Medical GmbH, Isny, Germany) was used for converting information received from this platform into digital data and transferring it to the computer.

Center of pressure (COP) was evaluated in two positions with the eyes open and eyes closed on both the feet. During the measurements, precautions were taken to avoid any noise, and the ambient temperature was set to room temperature. The procedure was demonstrated to the subjects and a trial measurement was taken without recording the results. The subjects were instructed to stand upright on the platform with their eyes open (EO), arms parallel to the floor, and palms facing downward while looking at the image placed at eye level 2-m away from the force platform (Fig. 1). After the computer program calibrated the system, the anteroposteriorly aligned designed line between the two naviculare bones was shifted to coincide with the central axis of the platform. Data were collected for 20 seconds. After each measurement, the subjects rested for 2 minutes, and each measurement was repeated thrice. After resting for 5 minutes, the same procedure was repeated in the same position with their eyes closed (EC).

Figure 1. Balance analysis position

Table 1. Demographic and anthropometric features

	Control (n=31)	Patient (n=35)	p
Age (year)	37.23±11.47	41.06±9.63	0.222
Height (cm)	168.61±10.58	170.97±8.41	0.440
Weight (kg)	76.55±14.43	74.80±15.06	0.643
Body mass index	26.80±3.42	25.41±3.83	0.069

Independent sample t-test

The confidence ellipse containing 95% of the points where the COP is located during the measurement was determined. The area of this ellipse and the angle between its long axis and the Y-axis (COP angle), the distance traveled by the center of pressure, path length (PL), the deviation in the anterior and posterior directions on the X-axis (AP), and the deviation in the mediolateral direction on the Y-axis (ML) were obtained as a result of the measurement.

Statistical Analysis

SPSS 20.0 program (IBM SPSS software, USA) was used for statistical analysis. The results were presented as mean±standard deviation (SD), median, and quartiles (Q). In order to check the conformity of the variables to the normal distribution, the "Single Sample Kolmogorov Smirnov test" was used. Descriptive statistics (mean, SD, median, and quartiles) were used in the analysis of the results. Student's t-test was used in comparing the age, height, weight, and body mass index (BMI). The Mann–Whitney U test was used for group comparisons since the data from COP were not normally distributed. The threshold for statistical significance was set at $p<0.05$.

Table 2. Balance analysis data with eyes open

	Control (n=31)			Patient (n=35)			p
	Median (Q1–Q3)	Min	Max	Median (Q1–Q3)	Min	Max	
Anteroposterior deviation (mm)	10 (5–19)	0	33	9 (3–20)	0	43	0.985
Mediolateral deviation (mm)	8.5 (3–16.2)	0	54	16 (7–29)	1	84	**0.035***
Area of ellipse (mml)	46.5 (32.2–117.5)	12	399	62 (34–117)	2	480	0.923
Path length of center of pressure (COP, mm)	165 (134.5–203)	106	524	213 (148–279)	100	839	**0.042***
COP angle (°)	28 (9–59.2)	1	90	13 (6–38)	2	85	0.129

Mann–Whitney U test. *: Significant difference (p<0.05) between the two groups; COP: Center of pressure; Min: Minimum; Max: Maximum

Table 3. Balance analysis data with eyes closed

	Control (n=31)			Patient (n=35)			p
	Median (Q1–Q3)	Min	Max	Median (Q1–Q3)	Min	Max	
Anteroposterior deviation (mm)	11 (5–24)	1	71	16 (7–20)	3	92	0.709
Mediolateral deviation (mm)	11 (4–22)	1	58	18 (6–28)	0	83	0.217
Area of ellipse (mml)	65 (41–90)	16	582	72 (39–152)	11	605	0.382
Path length of center of pressure (COP, mm)	204 (175–248)	131	1048	275 (217–352)	146	739	**0.002***
COP angle (°)	14 (5–23)	0	77	18 (7–32)	2	87	0.252

Mann–Whitney U test. *: Significant difference (p<0.05) between the two groups; COP: Center of pressure; Min: Minimum; Max: Maximum

RESULTS

The age, height, weight, and BMI data of the two groups were statistically compatible (p=0.222, p=0.440, p=0.643, and p=0.069, respectively) (Table 1). The mean age of the patients at the onset of symptoms was 30.29±9.73 years. The mean age at diagnosis of AS was 33.61±9.3 years. The average time between the onset of symptoms and diagnosis was 3.32±4.72 year (median=0, min=0, max=16, Q1=0, Q3=6). The mean BASDAI score was 1.63±1.2.

Mediolateral displacement of the center of gravity (p=0.035) and total path length (0.042) were significantly higher when measured in the EO condition in the patient group. However, there were no significant differences in the anteroposterior deviation (p=0.985), area of ellipse (p=0.923), and COP angle (p=0.129) (Table 2).

The total path length center of the pressure (p=0.002) was significantly longer in the patient group when measured in the EC condition. The difference in anteroposterior deviation (p=0.709), mediolateral deviation (p=0.217), area of ellipse (p=0.382), and COP angle (p=0.252) data of the two groups were not statistically significant (Table 3).

DISCUSSION

AS is a chronic inflammatory disease that affects the bones and enthesis areas of the spine (19). Mechanical stiffness and associated joint pain caused by inflammation can limit axial mobility (20). This has a negative impact on postural control in patients with AS (20). In addition to the biomechanical change, inflammation in the enthesis areas affects nerve endings in the joint capsule and Golgi tendon organ (21). Chemosensitive nociceptors in the vertebral joints, muscles, and tendons lead to decreased proprioceptive acuity by altering muscle spindle sensitivity with reflex activation of fusimotor neurons (21). There are studies which use the tandem walking test, step and quick turn test (22), the force platform (23), and Biodex balance system (24) in order to assess static and dynamic balance in patients with AS (9). In this study, the tests were performed in the EO and EC conditions for investigating the effect of visual input.

In our study, we evaluated the static balance abilities of patients with AS in EO and EC conditions by using a force platform. The total displacement of the COP was greater in the patient group than in the control group in both the conditions. The shift of the COP in the mediolateral direction was greater in the patient group in EO condition. Vergara et al. (20) discovered that the displacement of the COP in the frontal and sagittal planes was greater in the patient group. Closed eyes negatively affected the displacement of the pressure center in the frontal plane in the patients with AS but no difference was observed in the control group (20). de Nunzio et al. (9) revealed that postural stability was worse in the EC condition. The change in the COP observed in our data in both the EO and EC conditions suggests that the problem was previously biomechanical in origin. Therefore, this parameter should be considered in patient exercise studies.

The results of the current study are contradictory to the studies wherein Biodex balance systems were used. In a previous study using this system, Durmus et al. (25) found that the patient group had higher values for overall, anteroposterior, and mediolateral stability index. In another study that used the same method, it was found that there was no difference between two groups on these parameters, but the patient group had a higher fall risk index (8). Although Acar et al. (24) found no difference between the two groups in the dynamic balance analysis, they discovered that the balance of the patient group was worse in the static balance analysis.

Although the results of the studies vary, the general opinion is that the patients with AS have impaired balance (8, 20, 24, 25). However, no association between impaired balance and disease severity has been found (5). A previous study that investigated the fall risk in patients with AS revealed a significant association among the number of falls and age, disease duration, fear of falling, and hip joint involvement. In the same study, the forearm was found to be commonly fractured when patients fell during the assessment (26). There are also studies on the effectiveness of rehabilitation programs for helping the patients in managing this risk and improving postural stability (21, 27). Demontis et al. (21) demonstrated that a multidisciplinary rehabilitation program supervised by a physiotherapist improves postural control in patients with AS.

The posture continues to deteriorate in patients with AS as the disease progresses (6). In addition, the pathological changes in the joints may damage the receptors located in the joint capsule, ligaments, and tendons that are sensitive to position sense (28). Thus, negative influence on proprioceptive sensation may cause deterioration of postural control. We observed a negative impact of visual input on postural control in this study. In balance analysis with EO, the deviation of the COP in the mediolateral direction was higher in the patients with AS than in the healthy group, while there was no difference in the balance analysis between these groups in the EC condition. When we subtracted visual input, which is one of the sensory components involved in maintaining balance, only a few parameters varied, suggesting that proprioceptive sensation from the joints was not as affected as was expected. However, since we did not compare the balance data of the EO and EC groups, we cannot conclude on the same. In addition, previous studies have shown that the elimination of visual input results in a worse balance performance in patients with AS (9, 20). In our study, we found that the total path length data was higher in the patient group, irrespective of the eye open or closed conditions. Takacs et al. (29) showed that total path length data were the most reliable for standing balance analysis and the anteroposterior deviation and COP area data were the least reliable data sets. Based on this, we can suggest that the balance of the patient group is worse than that of the control group in both the conditions.

There are some limitations of our study. First, the BASDAI scoring method that we used in selecting the participants of the patient group is not an objective method. Second, although we have selected participants with a BASDAI score of <4, the patients still had some pain that may have adversely affected postural balance.

CONCLUSION

Similar to the results of previous studies, we found that AS negatively affected the patient's balance. While there was a significant difference in two tested parameters in the EO condition, we saw a significant difference in only one parameter in the test with the EC condition. Since this disease usually occurs in the young population, balance impairment should be considered as a crucial factor complicating their daily and professional life. We propose that it would be beneficial to include balance exercises and other exercises that will reduce postural deformities in the rehabilitation programs for the patients with AS.

Acknowledgements: The authors thank the staff of the physical medicine and rehabilitation department for helping with data collection.

Ethics Committee Approval: The Trakya University Clinical Research Ethics Committee granted approval for this study (date: 27.04.2016, number: 08.04).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – MK, MP, AZYK, EU, NT; Design – MK, MP, AZYK, EU, NT; Supervision – MK, MP, AZYK, EU, NT; Resource – MK, MP, AZYK, EU, NT; Materials – MP, NT; Data Collection and/or Processing – MK, MP, AZYK; Analysis and/or Interpretation – MK, EU; Literature Search – MK, EU; Writing – MK; Critical Reviews – MK, EU, NT.

Conflict of Interest: The authors have no conflict of interest to declare.

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

REFERENCES

1. Lee J. Did Sejong the Great have ankylosing spondylitis? The oldest documented case of ankylosing spondylitis. Int J Rheum Dis 2021; 24(2): 203–6. [CrossRef]
2. Halvorsen S, Vøllestad NK, Fongen C, Provan SA, Semb AG, Hagen KB, et al. Physical fitness in patients with ankylosing spondylitis: comparison with population controls. Phys Ther 2012; 92(2): 298–309.
3. Cınar E, Akkoc Y, Karapolat H, Durusoy R, Keser G. Postural deformities: Potential morbidities to cause balance problems in patients with ankylosing spondylitis? Eur J Rheumatol 2016; 3(1): 5–9. [CrossRef]
4. Del Din S, Carraro E, Sawacha Z, Guiotto A, Bonaldo L, Masiero S, et al. Impaired gait in ankylosing spondylitis. Med Biol Eng Comput 2011; 49(7): 801–9. [CrossRef]
5. Murray HC, Elliott C, Barton SE, Murray A. Do patients with ankylosing spondylitis have poorer balance than normal subjects? Rheumatology (Oxford) 2000; 39(5): 497–500. [CrossRef]
6. Gokcen N, Sariyildiz A, Coskun Benlidayi I. Static foot posture and its relation to clinical variables in ankylosing spondylitis. Int J Rheum Dis 2021; 24(9): 1148–52. [CrossRef]
7. Sawacha Z, Carraro E, Del Din S, Guiotto A, Bonaldo L, Punzi L, et al. Biomechanical assessment of balance and posture in subjects with ankylosing spondylitis. J Neuroeng Rehabil 2012; 9: 1–11. [CrossRef]
8. Aydog E, Depedibi R, Bal A, Eksioglu E, Unlü E, Cakci A. Dynamic postural balance in ankylosing spondylitis patients. Rheumatology (Oxford) 2006; 45(4): 445–8. [CrossRef]
9. de Nunzio AM, Iervolino S, Zincarelli C, Di Gioia L, Rengo G, Multari V, et al. Ankylosing spondylitis and posture control: the role of visual input. Biomed Res Int 2015; 2015: 948674. [CrossRef]
10. Lee JS, Suh KT, Kim JI, Goh TS. Analysis of sagittal balance of ankylosing spondylitis using spinopelvic parameters. J Spinal Disord Tech 2014; 27(3): E94–8. [CrossRef]
11. Sato T, Yonezawa I, Inoue H, Tada K, Kobayashi S, Hayashi E, et al.; Juntendo AS Research Group. Relationship between characteristics of spinopelvic alignment and quality of life in Japanese patients with ankylosing spondylitis: A cross-sectional study. BMC Musculoskelet Disord 2020; 21(1): 41. [CrossRef]
12. Jardak M, Chaari F, Bouchaala F, Fendri T, Harrabi MA, Rebai H, et al. Does piriformis muscle syndrome impair postural balance? A case control study. Somatosens Mot Res 2021; 38(4): 315–21. [CrossRef]

13. Sieper J, Braun J, Rudwaleit M, Boonen A, Zink A. Ankylosing spondylitis: An overview. Ann Rheum Dis 2002; 61(Suppl 3): iii8–18.
14. Soulard J, Vaillant J, Agier CT, Vuillerme N. Gait characteristics in patients with ankylosing spondylitis: A systematic review. Clin Exp Rheumatol 2021; 39(1): 173–86. [CrossRef]
15. do Nascimento JA, Silva CC, Dos Santos HH, de Almeida Ferreira JJ, de Andrade PR. A preliminary study of static and dynamic balance in sedentary obese young adults: The relationship between BMI, posture and postural balance. Clin Obes 2017; 7(6): 377–83. [CrossRef]
16. Nagymáté G, Kiss RM. Balancing strategy differences in bilateral knee osteoarthritis patients. 2017 13th IASTED international conference on biomedical engineering (BioMed). IEEE; 2017: 154–7. [CrossRef]
17. Byravan S, Jain N, Stairs J, Rennie W, Moorthy A. Is there a correlation between patient-reported bath ankylosing spondylitis disease activity index (BASDAI) score and MRI findings in axial spondyloarthropathy in routine clinical practice? Cureus 2021; 13(11): e19626.
18. Boel A, Molto A, van der Heijde D, Ciurea A, Dougados M, Gensler LS, et al. Do patients with axial spondyloarthritis with radiographic sacroiliitis fulfil both the modified New York criteria and the ASAS axial spondyloarthritis criteria? Results from eight cohorts. Ann Rheum Dis 2019; 78(11): 1545–9. [CrossRef]
19. Vecellio M, Chen L, Cohen CJ, Cortes A, Li Y, Bonham S, et al. Functional genomic analysis of a RUNX3 polymorphism associated with ankylosing spondylitis. Arthritis Rheumatol 2021; 73(6): 980–90.
20. Vergara ME, O'Shea FD, Inman RD, Gage WH. Postural control is altered in patients with ankylosing spondylitis. Clin Biomech (Bristol, Avon) 2012; 27(4): 334–40. [CrossRef]
21. Demontis A, Trainito S, Del Felice A, Masiero S. Favorable effect of rehabilitation on balance in ankylosing spondylitis: A quasi-randomized controlled clinical trial. Rheumatol Int 2016; 36(3): 333–9. [CrossRef]
22. Gunduz OH, Ozcan-Eksi EE, Giray E, Yagci İ. What impairs balance in ankylosing spondylitis? Posture or disease activity? Arch Rheumatol 2017; 32(3): 221–6. [CrossRef]
23. Bot SD, Caspers M, Van Royen BJ, Toussaint HM, Kingma I. Biomechanical analysis of posture in patients with spinal kyphosis due to ankylosing spondylitis: A pilot study. Rheumatology (Oxford) 1999; 38(5): 441–3. [CrossRef]
24. Acar Y, Ilçin N, Gürpinar B, Can G. Core stability and balance in patients with ankylosing spondylitis. Rheumatol Int 2019; 39(8): 1389–96.
25. Durmus B, Altay Z, Ersoy Y, Baysal O, Dogan E. Postural stability in patients with ankylosing spondylitis. Disabil Rehabil 2010; 32(14): 1156–62. [CrossRef]
26. Dursun N, Sarkaya S, Ozdolap S, Dursun E, Zateri C, Altan L, et al. Risk of falls in patients with ankylosing spondylitis. J Clin Rheumatol 2015; 21(2): 76–80. [CrossRef]
27. Gunay SM, Keser I, Bicer ZT. The effects of balance and postural stability exercises on spa based rehabilitation programme in patients with ankylosing spondylitis. J Back Musculoskelet Rehabil 2018; 31(2): 337–46. [CrossRef]
28. Swinkels A, Dolan P. Spinal position sense in ankylosing spondylitis. Spine (Phila Pa 1976) 2004; 29(4): 413–20. [CrossRef]
29. Takacs J, Carpenter MG, Garland SJ, Hunt MA. Test re-test reliability of centre of pressure measures during standing balance in individuals with knee osteoarthritis. Gait Posture 2014; 40(1): 270–3. [CrossRef]