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The use of baropodometry for the evaluation of plantar pressure distribution in ankylosing spondylitis

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Abstract

Aim: Ankylosing Spondylitis is among the most common inflammatory rheumatic diseases and associated with postural alterations. The aim was to investigate the baropodometric variations between patients with ankylosing spondylitis to detect whether postural alterations affect plantar pressure distribution.

Materials and Methods: The study population consisted of 41 patients with ankylosing spondylitis and 32 volunteers with compatible age and gender. Moreover, Visual Analog Scale, and Bath Ankylosing Spondylitis Metrology Index were used to determine the clinical conditions of the patients. Plantar pressure distribution was determined by static baropodometric measurements.

Results: There was no significant difference between two groups in terms of static baropodometric measurements ($p>0.05$). The lower peak pressures on the forefoot and rear foot are associated with higher BASMI, BASDAI, BASFI and ASQoL scores of the patients ($p< 0.05$).

Conclusion: Postural alterations might have an impact on plantar pressure in patients with ankylosing spondylitis.

Keywords: Ankylosing Spondylitis; Baropodometry; Postural Stability; Plantar Pressure.

INTRODUCTION

Ankylosing Spondylitis (AS) is a chronic inflammatory disease of unknown etiology with enthesis, peripheral joint and axial skeleton involvement (1,2). Spinal deformity generally arises at the early stages of the disease and they become more apparent at the advancing period of the disease (3). Ventral flexion of head and neck, increase of thoracic kyphosis, shortened hip and knee flexors are the characteristic postures of AS (4). Anatomical variations associated with vertebral ankylosis might end up with kyphosis, and reduce anatomical movement (5). In case of kyphotic deformity, body's center of gravity is shifted towards forward (6). The alterations in axial mobility might result in deterioration of postural control and balance disorder and even elevated risk of fall (7). The fears of fall and activity limitation are recognized by means of its contribution to the reduced quality of life (8).

There are only few studies evaluating the postural control in AS and their results were contradictory (9,10).

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Besides, any contribution of ankles has not been defined to this compensation. Foot is the supportive and stimulating basis of walking. It provides support and flexibility for effective weight transfer. The accurate biomechanics of the foot is responsible for the maintenance of symmetrical distribution of the body posture and plantar pressure (11). Baropodometric analyses evaluate foot dysfunction. The principle is indirectly mapping the plantar surface pressure indicating significant posture anomalies (12).

Dynamic baropodometry provides information regarding dynamic activities, and static baropodometry can analyze plantar pressure during standing position (13). It is divided into two groups; right and left foot; three subgroups as frontal, medial and posterior foot. This enables to determine the weight percentage supported by each foot and the symmetry ratio between them. Moreover, it can calculate an arc index notifying foot type: normal, cavus or plain. It also provides stabilometric parameters derived from spatial and temporal behavior of the pressure center as a force plane (14). The plantar pressure of the forefoot might increase due to the displacement of the body towards forward and downward in AS (15).

There are limited numbers of studies for the evaluation of baropodometry usage in the assessment of postural control (16). Therefore, the aim was to determine the presence of plantar loading dysfunction in AS patients by comparing to healthy control group, and to evaluate the relationship between alterations in potential plantar pressure and clinical findings.

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MATERIALS and METHODS

Forty-one patients diagnosed with axial SpA and thirty-two age- and sex-matched control subjects were included in this study. Baseline assessments were included demographic information (age, gender, and education), disease duration, medications (non-steroidal anti-inflammatory drugs [NSAIDs], anti-tumor necrosis factor [TNF]), serum C-reactive protein level (CRP), erythrocyte sedimentation rate (ESR), pain by visual analog scale (VAS), and measurements for disease activity, functional status, psychological status and health assessment.

The subjects were excluded if they had orthopedic problems of the lower extremities, a history of orthopedic surgery, neurological disorders involving the lower extremities, cognitive disorders, visual and hearing impairment, current complaint of foot pain and foot involvement of AS.

For all patients, written informed consent was obtained, and the protocol of the study was approved by the local Ethics Committee.

Disease activity and functional status: The Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) is an index used to determine the activity of AS. The index includes six questions about the levels of neck, back, lower back, and hip pain, fatigue, pain and swelling at peripheral joints, tenderness with palpation at several areas of the body, and morning stiffness, including its duration (17).

The Bath Ankylosing Spondylitis Functional Index (BASFI) was used to assess patient function. This scale is based on 10 questions about daily functioning, each scored on a 10-cm visual analogue scale (VAS), reflecting status over the past month (18). The reliability and validity of the Turkish version of BASDAI and BASFI have already been demonstrated (19,20).

Pain: In the VAS, the two extremes of the parameter being assessed are written at the edges of a 100-mm line, and the patient is asked to draw a line to or put a mark at the place that would indicate his or her status (21).

Measure of the quality of life: Disease-related quality of life was measured using the Ankylosing Spondylitis Quality of Life (ASQoL) scale (22). This questionnaire consists of 18 items with dichotomous responses (yes/no) and is reliable and valid for measuring the health-related quality of life in patients with AS. The reliability and validity of the Turkish version of this questionnaire was determined by Duruöz et al. (23).

Baropodometric measurements: Static measurements were done in a silent room and all participants were asked to stand as barefoot on 0.5 m capacity of pressure distribution platform (RScan International, Olen, Belgium) their head so as to look forward. Active sensor area of the platform was composed of 488x325 mm and 4096 sensors and data collection frequency was 300 Hz. When the patient came to proper position, snapshot of the measurement was obtained. Measurements were repeated twice and magnitude of pressure distribution was evaluated using foot scan walking software in four quadrants: The right forefoot (RFF), the right hind foot (RGF), the left forefoot (LFF) and the left hind foot (LHF). Relative pressure loads of all four quadrants (%) were recorded.

Statistical analysis

SPSS for Windows version 17.0 software was used for the statistical analyses of our study data. Student's t test was used to compare the numeric data between groups, and chi-square test to compare the categorical variables Correlation analyses were used to examine the associations between the independent variables by Pearson correlation test (r) values. $P < 0.05$ was considered statistically significant.

RESULTS

The data from 41 patients with AS and 32 healthy controls were analyzed. Demographic characteristics and clinical and laboratory features of the patients are summarized in Table 1.

Table 1. Demographic, clinical and laboratory variables.

Variables	AS (*n*=41) mean±SD	Control (*n*=32)mean±SD
Age (years)	41.7±9.4	39.8±5.7
Gender F/M	19/22	14/18
CRP (mg/dl)	7.2±7.1	
ESR (mm/h)	27±22.8	
HLA-B27 seropositivity *n*;%	27/3; 81.8	
VAS (0–100 mm)	43±16.6	
BASFI	3.1±1.5	
BASDAI	4.0±1.4	
ASQOL	7.6±3.7	
NSAID use *n*; %	44, 71.4	
Anti-TNF use *n*; %	35, 70.6	

ESR: erythrocyte sedimentation rate, *CRP:* C-reactive protein, *VAS:* Visual Analog Scale, *BASDAI:* Bath Ankylosing Spondylitis Disease Activity Index, *BASFI:* Bath Ankylosing Spondylitis Functional Index, ASQoL: Ankylosing Spondylitis Quality of Life, NSAID: non-steroid anti-inflammatory drugs.

There was no significant difference between two groups in terms of static baropodometric measurements (p>0.05) (Table 2).

Table 2. Intergroup comparison of plantar pressure distribution in static measurements.

Relative pressure-load (%)	AS (*n*=41)	Control (*n*=32)	*p*
Right forefoot	27.77 (2.77)	23.85 (3,16)	0.12
Right rear foot	25.24 (3.53)	24.25 (2.79)	0.17
Left forefoot	26.82 (2.87)	23.63 (3.84)	0.27
Left rear foot	24.97 (3.76)	24.44 (2.62)	0.08

*: Variables were expressed as mean ± SD

The lower peak pressures on the forefoot and rearfoot are associated with higher BASMI, BASDAI, BASFI and ASQoL scores of the patients (p< 0.05) (Table 3).

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Table 3. Correlation between the static plantar pressure measurements and clinical measures.

		BASDAI	BASFI	ASQOL
Right forefoot	r	−.176	−.160	−.154
	p	0.005	0.011	0.004
Right rearfoot	r	−.142	−.191	−.109
	p	0.000	0.006	0.003
Left forefoot	r	−.156	−.106	−.109
	p	0029	0.003	0.002
Left rearfoot	r	−.183	−.166	−.163
	p	0.003	0.002	0.005

BASDAI: Bath Ankylosing Spondylitis Disease Activity Index, *BASFI:* Bath Ankylosing Spondylitis Functional Index, ASQoL: Ankylosing Spondylitis Quality of Life

DISCUSSION

The static plantar foot pressure was similar between AS patients and control group. According to the shifting of COM in AS patients towards forward and downward, it was expected to measure a high pressure value especially in forefoot and midfoot rather than rear foot. Bot et al. detected that AS patients hardly extended their hips while standing which enhanced balance disorder by means of displacing the centre of gravity towards forward. In their biomechanical analyses, balance disorder associated with elevated thoracic kyphosis might be compensated with hip extension, knee flexion and ankle plantar flexion, and ankle plantar flexion was indicated as the most effective of those (5).

In a study conducted by Van Royen et al., postural alterations and balance preservation compensations were occurred correlatively in patients with vertebral deformation. It was reported that elevated hip extension was used in order to compensate the displacement of center of gravity, therefore, posture was preserved while standing. However, the efficacy of the compensation provided by the hip was decreased as deformation continued (3).

In the study of Swinkels, a possible association was defined between postural alterations and mobility limitation, antalgic position association with vertebral or sacroiliac joint inflammation and muscle weakness caused by potential primary denervation process. Characteristic alterations were determined including the flattening of lumbar lordosis, increase of thoracic kyphosis, upper cervical extension, and lower cervical flexion. In the same study, probable proprioceptive deficits were reported in AS patients. According the opinion of the writer, pathological involvement of the spinal enthesis resulted in proprioceptive deficits conceivably (24).

The measurement of planar pressure is an uncommon tool in the clinical practices. There are limited number of studies that were used baropodometry. Many of these studies are relevant to neurology or orthopedics.

For example, Bellizzi et al. used baropodometry for the evaluation of sudden and permanent weight distribution following sacroiliac joint loading with fast speed and low amplitude (12). Grassi et al. believed that sacroiliac joint manipulation might affect asymmetrical tension throughout pelvic complex and provide more equal distribution to the lower extremities. So, they used baropodometry for the evaluation of sudden and permanent weight distribution following sacroiliac joint loading with fast speed and low amplitude. They obtained a positive effect between the feet of asymptomatic population and also during one-week follow up period right after the manipulative intervention (25).

Lower plantar peak pressures in mid-and rear foots were associated with patients' high scores of BASDAI, BASFI and ASQoL. These findings were compatible the previous studies in which reverse correlation was determined between pain and peak plantar pressure under the forefoot and rear foot regions at the lower extremity (26,27).

Durmuş et al. investigated the association of postural stability with disease activity, functional condition and mobility at the early and late periods of AS patients, and they found high levels of balance index in both groups in comparison to control group. The test results of postural balance disorder were found to be significantly higher at the late periods in comparison to the early periods of the disease (10). Souza et al. reported that postural balance was worse in AS patients when compared to healthy individuals. They found a positive correlation between pain and balance (28).

CONCLUSION

Postural alterations might be effective on plantar pressure in patients with AS. This study is important since it investigates the distribution of plantar pressure in patients with AS. However, there are some limitations; dynamic postural control, and therefore, plantar pressure alterations occurring while walking could not be evaluated.

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