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Dynamic postural balance in ankylosing spondylitis patients

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***Objectives*. In this study, our objectives were to investigate whether patients with ankylosing spondylitis (AS) have a poorer dynamic balance than normal subjects, and to study the relationship between balance and posture.**
***Methods*. Seventy patients (57 men, 13 women) with AS and 35 (31 men, 4 women) controls matched for age, weight, height and body mass index were tested using the Biodex Stability System (Biodex Medical Systems, Shirley, NY, USA). Anteroposterior (AP), mediolateral (ML) and overall (OA) indices were obtained with bilateral stance at platform stabilities of 8 and 4. Subjects were tested with 'eyes open' at all times. Correlation analyses were performed between stability indices (OA, AP, ML) and disease duration, cervical rotation (CR), tragus to wall distance (TWD), lumbar side flexion (LSF), lumbar flexion (LF), intermalleolar distance (IMD) and Bath Ankylosing Spondylitis Metrology Index (BASMI) total score.**
***Results*. No significant difference was found between the AS patients and healthy subjects with respect to all three stability indices at levels 4 and 8. A positive correlation was found only between ML stability index and TWD at level 8 (r, 0.249; $P = 0.038$). No other positive correlation was detected between stability indices and CR, TWD, LSF, LF, IMD, total BASMI score and disease duration.**
***Conclusions*. AS has no negative effect on postural stability. The only clinically significant association was found between dynamic postural balance and TWD.**

KEY WORDS: Ankylosing spondylitis, Postural balance, BASMI, Biodex Stability System.

Ankylosing spondylitis (AS) is defined as the formation of a stiff joint by consolidation of the articulating surfaces and inflammation of the vertebral column. Nevertheless, the characteristic lesion in AS is sacroiliitis [1]. Changes in spinal posture usually begin in early disease, becoming more marked over time. In AS, the spine becomes a rigid beam of bone from the occiput to the sacrum. With few exceptions, AS also leads to a rigid thoracolumbar kyphotic deformity. Consequently, the patient stands in a stooped position and is unable to see the horizon [2]. The kyphotic deformity may restrict a patient's activities of daily living such as interpersonal communication, driving a car, walking down the street or maintaining personal hygiene. Poor posture may also induce impairment of balance in AS patients. Loss of balance in AS patients is associated with severe joint deformities and falls [3]. Understanding the impact of AS on balance may elucidate the possible mechanism of disability in this patient population, and may permit more effective management of patients with the disease. Although postural changes have also been implicated in impairment of balance in other clinical areas, there are few studies in the literature about balance problems in AS patients [4]. Khan [5] commented that AS patients may injure themselves more readily because of the rigid spine that impairs their ability to balance themselves after sudden changes of position. Murray *et al.* [4] were the first to show by quantitative measurements that a significant proportion of AS patients have poorer balance than normal subjects.

Balance is a complex function involving numerous neuromuscular processes [6, 7]. Balance is controlled by sensory input, central processing and neuromuscular responses. The sensory components include the vestibular, visual and proprioceptive systems. An effective motor response requires an intact neuromuscular system and sufficient muscle strength to return the centre of mass within the base of support when balance is disturbed. Control of balance is essential in all postures and situations, both static and dynamic. Falls and loss of balance most commonly occur during movement-related tasks such as walking and less frequently during static activities. It is therefore important that the evaluation of balance incorporates testing procedures that reflect the dynamic nature of such locomotor tasks, as static tests of balance are less efficient than dynamic tests in identifying individuals at risk of falls [8, 9]. The Biodex Stability System (BSS) is reliable for evaluating dynamic postural balance in healthy and blind people (ICC ranges from 0.59 to 0.95), and has been used to evaluate postural balance in recent years [10–14].

The purpose of this study was to evaluate dynamic standing balance in individuals with AS and in a control group matched for age, gender and body mass index (BMI). An attempt was also made to determine whether there was any association within the AS group between dynamic balance and posture.

Patients and methods

Seventy patients (57 male, 13 female) with AS and 35 controls (31 male, 4 female) in the same age group participated in the study. The study was approved by the hospital's ethics committee and informed consent was obtained from all patients and controls. All patients met the most recent modified New York criteria. Patients who had had AS for at least 1 yr were included. Exclusion criteria were age older than 75 yr, concomitant cardiovascular, neurological or psychiatric disease, severe visual or auditory impairments (reduced visual acuity was accepted if adequately corrected) and use of sedatives. Patients with orthopaedic problems in the lower extremities due to other problems and

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FIG. 1. A patient in the balance test.

patients with active diseases were also excluded. The AS patients did not receive any physical therapy during the study to avoid the possibility of modifying their balance. All patients were tested with BSS in the early afternoon to eliminate morning stiffness.

To assess balance and neuromuscular control, this study used a commercially available balance device, the BSS (Biodex, Inc., Shirley, NY, USA), which consists of a movable balance platform that provides up to 20° of surface tilt in a 360° range of motion. The platform is interfaced with computer software (Biodex, Version 3.1, Biodex, Inc.) that enables the device to serve as an objective assessment of balance (Fig. 1). The measure of postural stability includes the overall (OA), the anteroposterior (AP) and the mediolateral (ML) stability scores. A high score in the OA index indicates poor balance. The OA stability score is believed to be the best indicator of the overall ability of the patient to balance the platform [14].

We assessed bilateral stance at level 8 and level 4 (level 8 being the most stable and level 1 the most unstable) with the BSS over a period of 20 s. Subjects were asked to step on to the platform of the BSS and assume a comfortable position while maintaining slight flexion in the knees (15°), to look straight ahead, and to place arms across the chest. Foot position coordinates were constant throughout the test session. Subjects were tested without footwear at all times. Patients and controls were trained for 1 min for adaptation to the machine, following which three practice trials, to reduce any learning effects, and three test evaluations were performed. A mean score was calculated from the three test evaluations. Subjects were given a 1-min rest between tests. All subjects were evaluated with their eyes open. The order of testing, with level 4 or level 8, was chosen randomly. We tested rheumatoid arthritis patients and healthy controls at levels 2 and 8 in a previous study. With the platform in a more unstable position (level 2), stability was disturbed to a much greater extent and some required the support handle. Since 11 of the patients (15.9%) and 3 of the controls (7.4%) could not complete the test [15], level 2 was not used in this study.

We evaluated the axial status of AS patients using Bath Ankylosing Spondylitis Metrology Index (BASMI). The BASMI consists of five measurements: cervical rotation (CR), tragus to wall distance (TWD), lumbar side flexion (LSF), lumbar flexion (LF) and intermalleolar distance (IMD). Cervical rotation was measured with a goniometer, and the mean of right and left results was calculated. The patient lies supine in the neutral position and the goniometer is placed centrally on the forehead. The patient is then asked to turn the head as far as possible to the right and then to the left. The TWD was assessed by a standard method. The patient stands with heels and buttocks touching the wall, with knees straight and shoulders back, and places the head as far back as possible, keeping the chin turned in. The LSF was measured using the fingertip to floor distance in full lateral flexion without flexing forward or bending the knees, using a ruler mounted on a floor stand. The patient bends laterally to push the middle finger of the right or left hand down the ruler, and the difference between start and end points is recorded. Lumbar flexion was assessed using the modified Schober index. A mark was placed at the lumbosacral junction, which is represented by the spinal intersection of a line joining the dimples of Venus. Further marks are placed 5 cm below and 10 cm above the lumbosacral junction. The patient is asked to bend forward as far as possible, keeping the knees straight, and the difference between these two marks is recorded. The IMD was measured with the patient supine, with knees straight and the feet pointing straight up. The patient was asked to separate their legs as far as possible and the distance between the malleoli was measured [16]. BASMI mobility measurements were taken by the same person at the same time of the day.

The SPSS 10.0 program was used for statistical evaluation (SPSS, Chicago, IL, USA). The level of statistical significance was accepted as $P < 0.05$. Difference in age, height, weight and BMI between patients and controls was tested using independent sample *t*-tests. Difference in gender between patients and controls was tested using the χ^2 test. Except for level 8 ML (where an independent samples *t*-test was used), a Mann–Whitney *U*-test was used for the difference in balance index between patients and controls because balance index values did not show the normal distribution. Pearson's correlation coefficients were calculated to evaluate the AS group regarding the influence of disease duration, CR, TWD, LSF, LF, IMD and BASMI total score upon postural control.

Results

The demographic and anthropometric features in AS and healthy subjects are shown in Table 1. There were no significant differences between the groups with respect to age, gender, height, weight or BMI.

The mean disease duration of the patients were 14.00 ± 8.43 yr (range 1 to 35 yr). The mean mobility scores, on the other hand, were: CR $51.60 \pm 21.02°$ (range 0–89°), TWD 19.56 ± 7.38 cm (range 9–50 cm), LF 3.07 ± 2.10 cm (range 0–8 cm), LSF 7.28 ± 4.44 cm (range 0.5–20 cm), IMD 86.11 ± 21.25 cm (range 36–134 cm) and BASMI 4.81 ± 2.42 (range 0–9).

Results for dynamic postural stability in the different groups are shown in Table 2. The results were based on the average of the three tests recorded at each stability level. The AP, ML and OA stability indices in the AS group were not significantly higher than in controls at level 8 and level 4.

Correlation analyses were performed between the stability indices (OA, AP, ML) at level 4 and level 8 and disease duration, CR, TWD, LSF, LF, IMD and BASMI total score. A positive correlation was found between the ML stability index and TWD at level 8 ($r = 0.249$, $P = 0.038$). No other positive correlation was detected between stability indices and CR, TWD, LSF, LF, IMD or total BASMI score and disease duration.

TABLE 1. The demographic and anthropometric features in AS and healthy subjects (ranges in brackets)

	AS patients	Control group	*P* value
Age (yr)	40.68 ± 10.43 (18–72)	37.47 ± 9.65 (23–67)	0.127
Height (cm)	164 ± 8.56 (145–185)	1.66 ± 7.24 (150–187)	0.205
Weight (kg)	67.61 ± 13.69 (37–100)	69.11 ± 8.51 (51–105)	0.493
BMI	25.26 ± 5.08 (16.53–41.23)	25.05 ± 2.75 (18.71–32.28)	0.790
Male/female	57/13	31/4	0.349

TABLE 2. Results of stability testing

		AS	Control	*P* value
Level 8	OA	3.29 ± 1.54	3.08 ± 1.18	0.575
	AP	2.38 ± 1.40	2.14 ± 1.03	0.459
	ML	2.28 ± 0.94	2.29 ± 0.73	0.528
Level 4	OA	3.61 ± 2.16	3.69 ± 1.76	0.234
	AP	2.74 ± 1.80	2.82 ± 1.43	0.176
	ML	2.35 ± 1.31	2.51 ± 1.08	0.139

Discussion

In this study, we investigated whether patients with AS have poorer dynamic balance than normal subjects, and studied the relationship between balance and the axial status of AS patients. The results showed that AS patients may have no dynamic postural instability. Postural balance was not affected by disease duration, CR, LSF, LF, IMD or BASMI total score. The only positive correlation was found between TWD and postural balance at level 8.

Ankylosing spondylitis leads to total immobility of the spine, and a fixed kyphosis may appear. From a biomechanical point of view, the spinal kyphosis causes a forward and downward shift of the centre of mass (COM) of the trunk in the sagittal plane, which induces a forward and downward shift of the body's COM with respect to the base of support. To maintain body balance, a patient has to correct for this shift. Due to the ankylosis of the spine, only the mobile joints of the lower limbs compensate for the sagittal displacement of the trunk COM. Extension of the hips, flexion of the knees and plantar flexion of the ankles may counterbalance the forward shift of the body COM relative to the base of support. Compensation by the ankles is very efficient, as it demands little plantar flexion of the ankle joints. When the hips are used for compensation, a larger change in joint angle is needed to obtain the same result concerning the COM displacement when compared with compensation by the ankle joints. Nevertheless, extension of the hips is beneficial, as it induces a posterior rotation of the pelvis and results in a large increase in trunk angle. The compensation may become insufficient due to the progress of the disease, which could lead to a permanent displacement of the trunk COM [17]. Postural changes may induce impairment of balance in AS patients. In this study we did not find poor balance in AS patients. Murray *et al.* [4] suggested that poor balance was not a problem for all AS patients, and that the majority was within normal limits. However, they showed that a significant proportion of AS patients have poorer balance than healthy controls both with eyes open and eyes closed. They found no relationship between balance and disease severity. The authors clarified that the statistical power of the study did not permit a weak association with severity to be excluded, and thus more patients would need to be studied to detect such a relationship [5].

Another reason for poor balance in AS patients may be impairment of proprioception. Pathological processes in AS have a high specificity for spinal entheses, which are the axial sites of attachment of joint capsules, ligaments and tendons into bone. Such attachment sites contain afferent nerve endings capable of relaying information on posture and movement of the spine, so pathology occurring here may lead to impairment of proprioception. However, Swinkels and Dolan [18] found that the sense of spinal position was not affected by disease progression in patients with mild AS. They suggested that impairment of proprioception may be compensated for by input from other unaffected structures and that longer follow-ups may help determine any association between disease-related postural change and sense of spinal position.

Why was there no poor balance demonstrated in AS patients in our study? We suggest two possible explanations. Firstly, a positive correlation was found only between ML stability index and TWD at level 8, thus a higher TWD indicates poorer balance. The TWD is an objective measurement of dorsal kyphosis. A TWD of more than 30 cm demonstrates severe disease. Since only three of our patients had a TWD above 30 cm, this may explain why there was no balance impairment shown in our study with AS patients. Secondly, there may indeed be an impairment in balance in AS, but this may be compensated for by other unaffected structures (joints). Bot *et al.* [17] showed that patients with spinal kyphosis compensate for displacement of trunk COM by flexion of the knees and/or plantar flexion of the ankles. In that study, the data suggested that the hip joints are at least no longer involved in balance control. In our study, we evaluated hip joints using measurement of IMD. There were 13 (18.6%) patients in this study with severe hip involvement (IMD < 70 cm). The remaining patients had moderate or mild hip involvement. There was no knee or ankle involvement in our patients. In our study, postural balance may have been compensated for by hip, knee and ankle joints.

Conclusions

Ankylosing spondylitis had no negative effect on postural stability in this study. The only clinically significant association was found between dynamic postural balance and TWD. Postural balance in AS patients may be compensated for by other unaffected joints. Patients with severe postural deformity need to be studied to detect such a relationship.

The authors have declared no conflicts of interest.

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