How does Spinal Mobility Affect Balance and Postural Control in Patients with Ankylosing Spondylitis? A Cross-Sectional Study

Wie wirkt sich die Wirbelsäulenbeweglichkeit bei Patienten mit ankylosierender Spondylitis auf das Gleichgewicht und die Haltungskontrolle aus? Eine Querschnittsstudie

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ABSTRACT

Purpose Alterations in spinal mobility lead to impaired postural control and balance, an increased risk of falls and a decrease in quality of life. The purposes of this study were to investigate the relationship between spinal mobility, postural control and balance and to compare spinal mobility and balance with a view to disease severity in patients with ankylosing spondylitis (AS).

Methods 137 patients with AS were divided into 2 groups by tragus-to-wall distance (TWD): (Group I = mild AS, n = 51), (Group II = moderate AS, n = 86). Balance was assessed with the Single-Leg Balance Test, the Timed Up and Go Test (TUG) and the Berg Balance Scale (BBS). Spinal mobility was measured by BASMI Index [TWD, cervical rotation (CR), Modified Schober Test (MST), lumbar lateral flexion (LLF), intermalleolar distance (IMD) and thoracic expansion (TE)] and was compared between the groups. The association with balance was investigated.

Results Spinal mobility and BBS scores in Group II were worse than in Group I ($p < 0.05$). Static balance and TUG of the groups were similar ($p > 0.05$). Dynamic balance was weakly correlated with MST, LLF and IMM and moderately correlated with CR, TE and BASMI. Static balance was weakly correlated with spinal mobility ($p < 0.05$). There was no correlation between TWD and any balance domains ($p > 0.05$).

Conclusions In patients with AS, spinal mobility and dynamic balance worsen as the disease progresses, whereas static balance does not change. Such changes in mobility and balance can negatively affect patients' participation in daily life and increase their risk of falls. Therefore, detailed evaluation of balance, balance training and fall prevention approaches need to be implemented in the rehabilitation programs of patients with AS.

ZUSAMMENFASSUNG

Hintergrund Veränderungen der Wirbelsäulenbeweglichkeit führen zur Beeinträchtigung der Haltungskontrolle und des Gleichgewichts, einem erhöhten Sturzrisiko und einer Verminderung der Lebensqualität. Ziel dieser Studie war es, den Zusammenhang zwischen Wirbelsäulenbeweglichkeit, Haltungskontrolle und Gleichgewicht zu untersuchen und Wirbelsäulenbeweglichkeit und Gleichgewicht bei Patienten mit ankylosierender Spondylitis (AS) hinsichtlich des Schweregrads der Erkrankung zu vergleichen.

Methode 137 Patienten mit AS wurden nach Tragus-Wand-Abstand (TWD) in 2 Gruppen eingeteilt: (Gruppe I = leichte AS, n = 51), (Gruppe II = mittelschwere AS, n = 86). Das Gleichgewicht wurde mit dem Einbein-Gleichgewichtstest, dem Timed Up und Go Test (TUG) und der Berg Balance Scale (BBS) gemessen. Die Wirbelsäulenbeweglichkeit wurde mit dem BASMI-Index [TWD, zervikale Rotation (CR), Modifizierter Schober-Test (MST), lumbale Lateralflexion (LLF), Intermalleolarabstand (IMD), thorakale Expansion (TE)] gemessen und zwischen den Gruppen verglichen. Die Assoziation zwischen Wirbelsäulenbeweglichkeit und Gleichgewicht wurde untersucht.

Ergebnisse Die Wirbelsäulenbeweglichkeit und die BBS-Werte der Gruppe II erwiesen sich als schlechter im Vergleich zu Gruppe I (p < 0,05). Das statische Gleichgewicht und der TUG der beiden Gruppen waren gleich (p > 0,05). Das dynamische Gleichgewicht korrelierte schwach mit MST, LLF, IMD und mäßig mit CR, TE und BASMI. Das statische Gleichgewicht korrelierte schwach mit der Wirbelsäulenbeweglichkeit (p < 0,05). Es fand sich keine Korrelation zwischen TWD und den Gleichgewichtsdomänen (p > 0,05).

Schlussfolgerungen Bei Patienten mit AS verschlechtern sich mit fortschreitender Erkrankung die Wirbelsäulenbeweglichkeit und das dynamische Gleichgewicht, während das statische Gleichgewicht unverändert bleibt. Derartige Veränderungen der Beweglichkeit und des Gleichgewichts können sich negativ auf die Teilhabe der Patienten am täglichen Leben auswirken und das Sturzrisiko erhöhen. Deshalb müssen eine detaillierte Untersuchung des Gleichgewichts sowie Gleichgewichtstraining und Ansätze der Sturzprävention in die Rehabilitationsprogramme für Patienten mit AS integriert werden.

Introduction

Ankylosing spondylitis (AS) is a chronic progressive inflammatory disorder characterized by inflammatory involvement of axial anatomical structures [1]. The overall prevalence is between 0.1 % and 1.4 % [2]. Sacroiliitis, spondylitis, spondylodiscitis, spinal enthesitis, arthritis of the zygapophyseal, costovertebral and costosternal joints and the most characteristical bony fusion of the axial skeleton may occur and impairs the posture and spinal mobility [1]. Limited spinal mobility is a cardinal sign of AS, featuring strongly in the AS diagnostic criteria (Modified New York Criteria) [3]. Thoracic hyperkyphosis may deflect a person's center of mass backwards by itself, displace the head anterior, protrude the scapula, decrease the lumbar lordosis and increase the risk of fall backwards [4].

Falls are associated with restricted mobility; decline in the ability to conduct activities of daily living; and are precipitators of injury, placement in a nursing home and even death [5].

Balance disorders in AS may develop because of postural changes, muscle shortness, atrophy, joint involvement secondary to the disease, and movement limitations due to pain, and could be associated with an increased fall risk and decreases in the quality of life of the patients [5–7]. There are limited studies investigating the balance of the patients with AS, especially the relationship between balance and spinal mobility [8]. Therefore, the aims of the study are to investigate how balance is affected by the spinal mobility in patients with AS and to compare the spinal mobility and balance of the patients according to disease severity.

Methods

This study designed as a cross-sectional study. Ethics approval for this study was obtained from the local Ethics Committee. Informed consent was obtained from each patient before participation in accordance with the Declaration of Helsinki.

Subjects

One hundred and thirty-seven volunteers who were diagnosed as AS according to Modified New York criteria by a specialist in Norway were included in the study by a random sampling method. Patients were reached out and evaluated at a Thermal Treatment Center. Inclusion criterias were; having having been diagnosed with AS at least 1 year ago, to be ambulatory and being able to speak English. Exclusion criteria were having a significant visual, auditory loss or an ear problem that may affect balance (such as Meniere syndrome), having an orthopedic problem involving the lower extremity, a presence of a neurological disease affecting the balance.

Patients were grouped according to tragus-wall distance (TWD) [9]. Patients with TWD < 15 cm is classified as mild, 15–30 cm moderate and > 30 cm as severe AS. However, there were 7 patients with a distance of TWD > 30 cm and this number would not create a statistical difference, two groups were formed as TWD < 15 cm (Group I) and TWD ≥ 15 cm (Group II) (5).

Procedures

Demographic and anthropometric data (age, sex, body weight, height, and body mass index), duration of illness of the volunteers were recorded.

Outcome Measures

Timed up and go test (TUG)

Timed up and go test is used to evaluate the dynamic balance performance of people during movement. The patient is observed and timed while he rises from an arm chair, walks 3 meters, turns, walks back, and sits down again [10].

Berg Balance Scale (BBS)

Berg Balance Scale is used to determine the risk of falling and to evaluate the balance during functional activities. The total score is 56 and it indicates the best performance. Classification of scoring; 0–20: High, 21 – 40: moderate and 41 – 56: low fall risk [11, 12].

Single Leg Stance Test

Static balance of the patients were assessed by standing time of the patients under four conditions: The right or left feet, eyes open or closed. Time recorded with a stopwatch. The stopwatch was stopped when patients could stand for 45 seconds or more. Each condition was repeated three times and the average of the three replicates was recorded [13].

Bath Ankylosing Spondylitis Metrology Index

It measures the axial condition (cervical, dorsal, lumbar spine, buttocks and pelvic soft tissue) in patients with AS [14]. It has been developed to determine the clinical change in spinal movements and mobility. Five domains of clinical measurements are available at BASMI. These are; cervical rotation, tragus - wall distance, Modified Schober test, lateral lumbar flexion and intermalleolar distance.

The cervical rotation was measured using a goniometer placed on the same line as the nose while the patient was sitting in the chair, the maximum rotation to the right and left side were averaged. The distance between the tragus and wall was measured when the patient's heels touched against the wall, her/his jaw parallel to the horizontal plane, and her/his back to the wall. The mean of the right and left side distances was obtained.

The Modified Schober Test is used to evaluate the lumbar region mobility. While the patient was standing, the 5th lumbar spinous projection and 10 cm above were marked. The patient was asked to lean forward and the new distance between the markers was measured using a tape measure. Two measurements were made, and the highest value was recorded.

The lumbar lateral flexion was measured as the patient was bent to the right side, the distance between the ground and fingertip was measured. The same procedure is repeated for the left side and the average of the left and right-side measurements recorded.

Intermalleolar distance was measured as the distance between the medial malleoli when the patient was on her/his back, knees extended, and the legs were maximally open.

Thoracic expansion: Chest circumference was measured from the 4th intercostal projection during both in maximal inspiration and expiration, and the difference recorded. The highest value was recorded when measured two times.

Statistical Analysis

The Kolmogorov-Smirnov/Shapiro-Wilk tests were used for the determination of the normal distribution. Independent t-test was used to compare the values between the groups. Pearson correlation was used to examine associations between spinal mobility and balance measurements. $p < 0.05$ was considered as significant.

Results

The demographic characteristics of the patients are shown in ▶ **Table 1**.

While there was no difference between the groups in terms of age and disease duration, the BMI median was higher in the second group and the female gender ratio was higher in the first group.

Comparison of spinal mobility measurements between the groups is shown in ▶ **Table 2**. Cervical rotation, tragus - wall distance, Modified Schober test, lateral lumbar flexion, total BASMI score and thoracic expansion scores of group 1 were lower than the group 2. There was no statistically significant difference in terms of intermalleolar distance between the groups.

Comparison of balance measurements between the groups is shown in ▶ **Table 3**. Berg Balance Scale scores of Group 2 were lower than the Group 1. There was no statistically significant difference in terms of Timed Up and Go Test and Single Leg Stance Test.

Relationships between spinal mobility and dynamic balance are shown in ▶ **Table 4**. Berg Balance Scale was positively and poorly correlated with the Modified Schober test, cervical rotation, lumbar lateral flexion, intermalleolar distance, BASMI score and thoracic expansion (r = 0.20, 0.30, 0.19, 0.29, 0.32 respectively, $p < 0.05$).

Timed Up and Go Test was negatively and poorly correlated with the Modified Schober test, cervical rotation, lumbar lateral flexion, intermalleolar distance, BASMI score and thoracic expansion (r = −0.25, −0.17, −0.19, −0.23, −0.23, −0.18 respectively, $p < 0.05$).

Relationships between spinal mobility and static balance are shown in ▶ **Table 5**. The time maintained when eyes open, on the right foot is positively and poorly correlated with cervical rotation, lumbar lateral flexion, intermalleolar distance and chest expansion, negatively and poorly correlated with the BASMI score (r = 0.26, 0.25, 0.20, −0.27

▶ **Table 1** Comparison of Demographic Characteristics Between the Groups.

Variables	Group 1	Group 2	p
	Mean ± Sd (Min-Max)		
Age (Years)	50.45 ± 9.42 (32–72)	51.64 ± 11.45 (20–78)	.532
Height (m)	1.71 ± 0.07 (1.57–1.88)	1.74 ± 0.10 (1.44–1.94)	**.002***
Weight (Kg)	75.28 ± 12.34 (48.20–105.30)	83.66 ± 16.33 (48.00–128.60)	**.035***
BMI (Kg/cm²)	25.65 ± 3.37 (17.49–33.50)	27.46 ± 3.37 (17.01–43.90)	**.017***
Gender (Female/Male)	36/15	27/59	**<.001****
Duration of Illness (Years)	17.83 ± 11.30 (1.00–50.00)	20.78 ± 9.67 (2.00–43.00)	.107
Employement status (Employee/Unemployee)	37/14	61/25	.841

* $p < 0.05$.

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▶ **Table 2** Comparison of Spinal Mobility Measurements Between the Groups.

Spinal Mobility Measurements	Group 1	Group 2	p
	Mean ± Sd (Min-Max)		
Tragus- wall distance (cm)	11.92 ± 1.80 (7.50–14.75)	21.20 ± 6.36 (15.00–53.00)	**<.001****
Cervical rotation (°)	54.20 ± 17.37 (14.50–90.00)	47.20 ± 20.60 (1.00–89.00)	**.036***
Lumbar lateral flexion (cm)	11.60 ± 4.25 (3.75- 23.50)	9.60 ± 7.03 (1.75- 59.00)	**.041***
Modified Schober test (cm)	3.12 ± 1.45 (0.8–6.00)	1.75 ± 1.15 (1.00–5.50)	**<.001****
Intermalleolar distance (cm)	95.77 ± 15.25 (61–126)	96.25 ± 19.56 (45–137)	.855
Thoracic expansion (cm)	3.67 ± 1.57 (0.50–8.50)	3.00 ± 1.52 (0.30–9.00)	**.008***
BASMI	3.00 ± 1.56 (0.50–8.50)	5.13 ± 1.82 (2.00–10.00)	**<.001****

* p < 0.05, BASMI: Bath Ankylosing Spondylitis Metrology Index.

▶ **Table 3** Comparison of Balance Measurements Between the Groups.

Balance Measurements	Group 1	Group 2	p
	Mean ± Sd		
Berg Balance Scale (0–56)	55.10 ± 2.12	53.40 ± 4.52	**.028***
Timed Up and Go Test (sn)	7.06 ± 1.20	7.45 ± 1.62	.126
EO, on the right foot	38.35 ± 10.80	34.82 ± 13.35	.112
EC, on the right foot	10.50 ± 8.27	8.40 ± 9.24	.185
EO, on the left foot	37.30 ± 10.24	34.68 ± 13.50	.236
EC, on the left foot	11.22 ± 10.13	8.37 ± 8.25	.075

* p < 0.05, EO: Eyes open, EC: Eyes closed.

respectively, $p<0.05$). The time maintained when eyes closed, on the right foot is positively and poorly correlated with Modified Schober test, lumbar lateral flexion, intermalleolar distance and chest expansion, negatively and poorly correlated with the BASMI score ($r=0.23, 0.20, 0.19, -0.26$ respectively, $p<0.05$). The time maintained when eyes open, on the left foot is positively and poorly correlated with cervical rotation, intermalleolar distance, thoracic expansion, negatively and poorly correlated with the BASMI score ($r=0.24, 0.28, 0.18, -0.24$ respectively, $p<0.05$). The time maintained when eyes closed, on the left foot is positively and poorly correlated with Modified Schober test and lumbar lateral flexion, negatively and poorly correlated with the BASMI score ($r=0.24, 0.20, -0.25$ respectively, $p<0.05$).

▶ **Table 4** Relationships Between Spinal Mobility and Dynamic Balance.

Variables		Berg Balance Scale	Timed Up and Go Test
Tragus- wall distance	r	− 0.145	0.140
	p	0.090	0.103
Modified Schober test	r	0.200	− 0.255
	p	**0.019***	**0.003***
Cervical rotation	r	0.300	− 0.179
	p	**<.001****	**0.036**
Lumbar lateral flexion	r	0.199	− 0.191
	p	**0.020***	**0.025***
Intermalleolar distance	r	0.269	− 0.231
	p	**<.001****	**<.001****
BASMI	r	0.324	− 0.273
	p	**<.001****	**<.001****
Thoracic expansion	r	− 0.260*	− 0.189
	p	**0.002***	**0.027***

* p < 0.05.

Relationships between clinical characteristics of the patients and the balance measurements are shown in ▶ **Table 6**. Berg Balance Scale is poorly and negatively correlated with BMI and duration of illness, moderately and negatively correlated with age ($r=-0.21, -0.34, -0.50, -0.29$ respectively $p<0.05$). Timed Up and Go Test scores was positively and poorly correlated with age ($r=0.25$, $p<0.05$). The time maintained when eyes open, on the right foot is poorly and negatively correlated with BMI and duration of illness, moderately and negatively correlated with age ($r=-0.19, -0.26, -0.50$ respectively $p<0.05$). The time maintained when eyes closed, on the right foot is poorly and negatively correlated with BMI and duration of illness, moderately and negatively correlated with age ($r=-0.19, -0.26, -0.50$ respectively $p<0.05$). The time maintained when eyes open, on the left foot is poorly and negatively correlated with BMI, duration of illness and age ($r=-0.22, -0.29, -0.37$ respectively $p<0.05$). The time maintained when eyes closed, on the left foot is poorly and negatively correlated with duration of illness and age ($r=-0.24, -0.34$ respectively $p<0.05$).

Discussion

Studies related to AS, reduction in spinal mobility and their effects on balance in patients with AS are limited. In this study, we evaluated the spinal mobility, static and functional or dynamic balance in patients with AS according to the severity of the disease and investigated the relationship between them. According to our results, spinal mobility and dynamic balance may worsen as the severity of the disease increases in patients with AS, however, the static balance does not change. Spinal mobility measurements were moderately correlated with dynamic balance and weakly correlated with static balance. There was no correlation between TWD and any balance domains.

▶ **Table 5** Relationships Between Spinal Mobility and Static Balance.

Variables		EO, right foot	EC, right foot	EO, left foot	EC, left foot
Tragus- wall distance	r	−0.130	−0.121	−0.067	−0.122
	p	0.129	0.158	0.439	0.155
Modified Schober test	r	0.099	0.231	0.102	0.249
	p	0.250	**0.007****	0.234	**0.003****
Cervical rotation	r	0.268	0.101	0.249	0.105
	p	**0.002****	0.241	**0.003****	0.222
Lumbar lateral flexion	r	0.177	0.202	0.139	0.205
	p	**0.039***	**0.018***	0.105	**0.016***
Intermalleolar distance	r	0.256	0.194	0.284	0.144
	p	**0.003***	**0.023***	**<.001****	0.093
BASMI	r	−0.270**	−0.216*	−0.244	−0.250
	p	**<.001****	**0.011***	**0.004****	**0.003****
Thoracic expansion	r	0.207	0.176	0.189	0.119
	p	**0.015***	**0.039***	**0.027***	0.165

* $p < 0.05$, EO: Eyes open, EC: Eyes closed.

▶ **Table 6** Relationships Between Clinical Characteristics of the Patients and the Balance Measurements.

Variables	Duration of Illness		Age		BMI	
	r	p	r	p	r	p
Berg Balance Scale	−0.341	**<.001****	−0.506	**<.001****	−0.215	**0.012****
Timed Up and Go Test	0.129	0.134	0.258	**0.002***	0.125	0.146
EO, right foot	−0.264	**0.002***	−0.505	**<.001****	−0.192	**0.025***
EC, right foot	−0.154	0.073	−0.545	**<.001****	−0.249	**0.003***
EO, left foot	−0.290	**<.001****	−0.377	**<.001****	−0.226	**0.008***
EC, left foot	−0.246	**0.004***	−0.348	**<.001****	−0.128	0.135

* $p < 0.05$, EO: Eyes open, EC: Eyes closed.

In patients with AS, as the severity of the disease progresses, spinal mobility and dynamic balance worsen; however, the static balance does not change. In addition, balance worsens with advancing age. These changes in postural control and balance can negatively affect patients' participation in daily life and increase their risk of falling. Sundström et at also reported that spinal mobility decreases with increasing disease severity and age [15]. Kuo et al. discussed that spinal mobility measures can identify the disease severity of AS [16]. Therefore, our study results are consistent with the literature.

With the progression of the disease, increase in thoracic kyphosis, decrease in lumbar lordosis, due to ankylosis in the spine and proprioception loss due to enthesity may cause muscle, balance disorders and postural instability [17]. In contrast to that, in our study, no correlation was found between thoracic kyphosis and static balance in patients with AS. In a study by Bot et al. , the biomechanical analysis of patients with AS showed that the balance disorder that caused by increased thoracic kyphosis is compensated by hip extension, knee flexion and ankle plantar flexion [18]. Therefore, we can conclude that the absence of a relationship between TWD and static balance could be due to this compensation mechanism. Consistent with our study, Gunduz et al. also showed that balance decreases with a decrease in spinal mobility and progressing disease [19]. Batur et al. concluded that AS can lead to balance deterioration due to spinal mobility changes [20].

Although, TWD was not associated with any balance measurements. We think that the reason for this could be the limited number of patients with advanced disease severity causing increased thoracic kyphosis or other compensation mechanisms.

Age was correlated with all balance parameters since balance worsens with the increasing age. The result is similar to the literature [21]. BMI and disease duration were also correlated with static balance measurements, but they were not correlated with Timed Up And Go Test. Disease duration does not seem like to affect functional data [21, 22] as similar to our study that reported the Timed Up And Go Test is not affected by the duration. However, static balance measurements were affected by the disease duration in our study as similar to the literature [23]. To our best knowledge, there is no study investigating the effect of BMI on static balance of AS compared with our study but Toy et al. found that increased BMI in patients with AS is a factor that affects the quality of life, disease activity, and functional capacity [24].

Limitations

The main limitation of our study was the lack of a healthy control group. Second, we could not investigate; though TWD reduction, patients showed no relationships between TWD and balance measurements. We did not question how much exercise patients does, therefore we do not know if it is because of regular exercise habits providing appropriate motor strength, flexibility and neural control.

Conclusions

In patients with AS, as the duration of the disease increases, spinal mobility and dynamic may balance worsen; however, the static balance does not change. These changes in the mobility and balance can negatively affect patients' participation in daily life and increase their risk of falling. The relationship between spinal mobility and static and dynamic balance shows that spinal limitations in patients with AS may affect the balance by themselves. There is also a strong relationship between age, BMI, duration of illness, static and dynamic balance.

Conflict of Interest

The authors declare that they have no conflict of interest.

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