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Alterations of postural sway in adolescent idiopathic scoliosis

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Research Article

Purpose: This study was aimed to compare the postural sway parameters on stabilometer between patients with adolescent idiopathic scoliosis (AIS) and healthy adolescents. **Material and methods:** Twenty (age between 10-18) patients (17 girls; 3 boys) who were referred to Department of Orthopaedics and Traumatology in Hacettepe University and twenty-eight healthy adolescents in the same age group (18 girls; 10 boys) were included in the study. Postural sway in dominant, nondominant, front and back sides during three conditions (eyes open, eyes closed, and monitor closed) were measured by using a Stabilometer. **Results:** The mean Cobb angle was 36.4±16 degrees in patients with AIS. Although there was no statistically significant difference, balance index score was higher in patients with AIS compared to healthy adolescents during eyes open condition. There was no statistical difference between groups ($p>0.05$) with the exception of significantly different scores during eyes closed trial of stabilometer on dominant side and monitor closed trial on back side ($p<0.05$). There was statistically significant difference in balance index scores during eyes opened, eyes closed, and monitor closed conditions in patients with AIS and healthy controls ($p<0.05$). **Conclusion:** Patients with AIS may develop postural behaviour adaptation due to their postural deviations to compensate postural oscillations. We suggest assessment in postural sway alterations in patients with AIS to understand the mechanism of postural instability during screening process. Further research and comparison with healthy controls is needed to understand the mechanisms of postural behaviour of AIS patients during static and dynamic postural assessments.

Key words: Scoliosis; adolescent idiopathic, Postural balance, Stabilometer.

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Adölesan idiopatik skolyozda postüral salınım değişiklikleri

Amaç: Bu çalışmanın amacı, Adölesan idiopatik skolyozlu (AİS) ve sağlıklı çocukların postüral salınım parametrelerini karşılaştırmaktı. **Gereç ve yöntem:** Çalışmaya Hacettepe Üniversitesi Tıp Fakültesi Ortopedi ve Travmatoloji polikliniğinde AİS tanısı konmuş 10-18 yaşları arasında 20 (17 kız; 3 erkek) hasta ile aynı yaş ve cinsiyette 28 sağlıklı kişi alındı. Postüral salınım, dominant ve dominant olmayan taraf, anterior ve posterior yönlerde gözler açık, gözler kapalı ve monitör kapalı olmak üzere üç farklı durumda stabilometre ile ölçüldü. **Sonuçlar:** AİS'li olguların ortalama Cobb açısı 36.4±16 derecedir. AİS'li olguların stabilometrede gözler açık değerlendirilen postüral salınımları, istatistiksel olarak anlamlı olmasa da aynı yaş ve cinsiyetteki sağlıklı kişilerden daha fazlaydı. Gözler kapalı stabilometre değerlendirmesinde dominant taraf açısından; ve monitor kapalı stabilometre değerlendirmesinde ise posterior taraf açısından gruplar arasında istatistiksel olarak anlamlı fark vardı ($p<0.05$). Gözler açık, gözler kapalı ve monitör kapalı değerlendirme skorlarında gruplar arasında denge indeks skoru açısından istatistiksel olarak anlamlı fark vardı ($p<0.05$). **Tartışma:** AİS'li çocuklar vücut deviasyonlarına bağlı postural salınımları kompanse etmek için postüral davranış adaptasyonu geliştiriyor olabilirler. Postüral salınım değişikliklerinin AİS'li çocuklarda değerlendirilmesinin tarama süreci sırasında karşılaşılan postüral instabilitenin anlaşılmasına katkı sağlayacağını düşünmekteyiz. AİS'li çocukların postüral davranış mekanizmalarının daha iyi anlaşılabilmesi için sağlıklı kişilerle sonuçlarının karşılaştırıldığı daha fazla statik ve dinamik postüral değerlendirme çalışmalarına ihtiyaç vardır.

Anahtar kelimeler: Skolyoz; adölesan idiopatik, Postüral denge, Stabilometre.

Adolescent idiopathic scoliosis (AIS) is a three dimensional deformation of the spine greater than 10 degrees as measured using Cobb method on a standing radiograph without any associated pathology. It develops most rapidly while child growing according to the Scoliosis Research Society.[1] There is still no generally accepted theory for the aetiology of AIS.[2] In spite of this unclearity, genetic troubles about family heredity, endocrin and histologic modification factors at the origin of fast and slow muscle fibers in spine muscles, and neurophysiological factors causing postural problems have been reported for the aetiology of AIS.[3]

Muscular imbalance in spine was reported in patients with AIS.[4,5] Poorer postural characteristics in patients with AIS were described when comparison to healthy children because of the multidimensional pathologic adaptation of vertebra.[6] Static postural behaviour adaptations are known in patients with AIS related to increases in oscillation ranges which can be shown with both centre of mass and pressure displacements compared to healthy group.[7,8] Sahlstrand et al were first who reported standing imbalance in this population.[9] Gauchard et al, has also reported significant differences between healthy adolescents and patients with AIS through dynamic and static balance tests.[10]

It was assumed that there is a relationship between postural deviations and postural sway behaviors of patients with AIS. Hypothesis of present study was that higher postural sways on stabilometer in patients with AIS than those of healthy adolescents could be triggered by postural deviations.

The aim of present study was to investigate adaptive postural sway behaviours of patients with AIS on stabilometer during three conditions (eyes open, monitor closed, and eyes closed) to compare the results with healthy controls. The authors anticipate that the results of this study would contribute to the AIS screening process by evaluating the deviations of postural sways in patients with AIS and healthy adolescents.

MATERIAL AND METHODS

This study was designed as a cross-sectional study. Twenty patients (17 girls; 3 boys) with AIS and 28 healthy adolescents (18 girls; 10 boys) were included in this study. Subjects were assessed via foot dominance testing to identify the dominant extremity and nondominant extremity. Each subject was asked to perform a single leg landing from a 20 cm high wooden box. The lower extremity initiating movement was defined as the "dominant lower extremity". All subjects had right side dominant in lower extremities. Patients with AIS were diagnosed by an orthopaedic surgeon. Inclusion criteria: Aged between 10 and 18 years without leg length discrepancy, hip flexion deformity, history of vertebral and lower extremity surgery. Exclusion criteria: Subject under active treatment, diagnosis of visual or vestibular illness which would interfere balance measurement. The healthy adolescents were verified by Department of Adolescent Health in Hacettepe University Hospital who were followed routinely for growing for absence of spinal deformity, visual or vestibular illness or physical limitations. All subjects and their parents gave their consent after being fully informed about the test procedure approved by the Institute of Health Sciences ethics committee of Hacettepe University (LUT 06/80)(07/12/2006).

Stabilometer:

Postural sway of patients with AIS and healthy controls was measured by using a Stabilometer (SportKat LLC-VISTA CA 92083, Kinesthetic Ability Trainer K.A.T.2000®). It provides graphical information which presents a trace as the subject's weight shifted in anteroposterior and mediolateral sides. Scores in right, left, front and back sides during assessment estimates balance index (BI) score to determine postural performance. Score is between 0-6000. Greater BI scores indicate a greater amount of postural instability or vice versa.[11]

The platform was first set to 2 Pressure Size Instrument (PSI) unit to expose subjects greater

postural oscillations. However, they could tolerate 3 PSI according to their age and weight (1 PSI=0.07 kg-force/cm^2). Subjects were asked to stand as quiet as possible on the platform with their feet oriented in a standard position, arms at their sides for a period of 30 seconds. The heels were spaced apart by about 15 cm while keeping their arms along their body. Subjects were asked to fix multiplication sign which had a distance about 45 cm located on monitor during quiet standing in eyes open trials. Then, subjects were tested in eyes closed and monitor closed conditions. Three conditions were tested three times. Each subject was given time to become familiarized with the procedure and was allowed three times trials prior to data collection. One minute rest period was allowed between each attempt and the mean scores were used.

Statistical analysis:

There was not a normal distribution as shown by Kolmogorov Smirnov test. This confirmed the use of nonparametric data analysis. Demographic data was compared with Mann Whitney U test between groups. Wilcoxon Signed Rank test was used to compare balance index scores during eyes open, eyes closed and monitor closed conditions within two groups. Differences with a significance level (p) less than 0.05 were considered significant.

RESULTS

Patients with AIS presented double major (44.3%) and thoracic curves (34.4%) with a mean Cobb angle of 36.4±16 degrees. Curve levels were between T_2 and L_3. Postural sway was measured in twenty patients with AIS and twenty-eight healthy adolescents using a stabilometer. While statistical differences were found in both groups in terms of height and weight ($p<0.05$); there was no significant difference for age and body mass index between the groups ($p>0.05$) (Table 1).

During eyes opened condition:

BI scores for right side were defined as dominant side scores. BI score of dominant and front side were similar in patients with AIS and healthy adolescents, while BI score of nondominant and back side were poorer in patients with AIS than healthy adolescents. There was no statistical difference in BI score between patients with AIS and healthy controls during eyes open condition ($p>0.05$) (Table 2).

During eyes closed condition:

There was statistical difference for dominant side between patients with AIS and controls in balance index score during eyes closed condition ($p=0.03$). Patients shifted their weight more to the dominant side than healthy controls, while no significant differences were found in BI scores between groups in nondominant, front and back sides ($p>0.05$) (Table 2).

During monitor closed condition:

Patients with AIS shifted their weight to back side more than controls. There was a significant difference between patients with AIS and controls for back side in BI score during monitor closed condition ($p<0.01$). However, there were similar BI scores in dominant, nondominant and front side between the groups ($p>0.05$) (Table 2).

Comparison of BI score between patients and healthy controls in different conditions:

Although there was no statistically difference, patients and healthy controls had better BI score tendency during eyes open condition ($p>0.05$), while they had poorer BI score during eyes closed and monitor closed conditions ($p<0.05$).

DISCUSSION

This study found that patients with AIS have significantly more oscillations during quiet standing than healthy adolescents in dominant and back side balance index score during eyes closed and monitor closed conditions except total balance index score during eyes open condition. Balance impairments in patients with AIS were first reported by Sahlstrand et al.[9] Several authors investigated balance in this population.[10-14] Chen et al found abnormalities with the center of mass in scoliotic patients.[7] Nault et al demonstrated a relationship between standing balance and postural deviations in scoliotic girls.[8] As in previous studies, we found similar alterations in postural control between patients with AIS and healthy adolescents.

Table 1. Demographic characteristics of patients and controls.

	Patients (N=20)	Controls (N=28)		
	X±SD	X±SD	z	p
Age (years)	14.5±2.2	15.1±1.7	-1.288	0.19
Height (cm)	155.9±11.2	162.9±8.2	-2.319	0.02*
Body weight (kg)	44.5±7.6	50.3±8.8	-2.565	0.01*
Body mass index (kg/m^2)	18.2±1.6	18.6±2.2	-0.952	0.34

* p<0.05.

Table 2. Comparison of balance index mean scores and standart deviations of stabilometer during eyes open, eyes closed, and monitor closed conditions between patients with AIS and controls.

	Patients (N=20)	Controls (N=28)		
	X±SD	X±SD	z	p
Eyes open				
Dominant side	158.7±122.0	152.9±72.6	0.207	0.83
Nondominant side	262.1±160.6	229.7±89.0	0.893	0.37
Front	219.2±191.8	217.3±110.1	0.044	0.96
Back	201.5±201.2	168.0±126.1	0.710	0.48
Eyes closed				
Dominant side	801.3±615.0	517.7±284.8	2.146	0.03*
Nondominant side	496.2±434.5	616.2±391.8	-0.999	0.32
Front	669.4±699.9	467.5±453.6	1.213	0.23
Back	628.1±427.3	649.5±342.0	-0.193	0.84
Monitor closed				
Dominant side	319.8±320.1	215.6±150.1	1.510	0.13
Nondominant side	440.4±483.9	405.8±280.0	0.313	0.75
Front	350.0±471.9	412.0±221.3	-0.609	0.54
Back	412.2±329.6	211.4±166.9	2.772	0.01*

* p<0.05.

Total BI score of patients with AIS and healthy adolescents were similar during eyes open condition. The possible reason for these similarities may be attributed to lack of study population. Although there was no significant difference between the groups during eyes open condition, patients with AIS had a tendency to have more postural oscillations than healthy adolescents. In addition, the possibility of peak scores which can effect the mean statistical differences can be responsible from the similarities in BI score. Yamada et al noted that visual feedback had an effect on balance control in scoliotic subjects.[15] Byl et al suggested to evaluate postural sways in different visual biofeedback conditions to understand the effect of visual stimulations on body oscillations related to balance.[16] They assessed 50 subjects with idiopathic scoliosis and 20 healthy subjects using stabilometer. They reported statistical differences

in postural sways during lack of visual and somatosensorial feedback between scoliotic and healthy subjects. Chen et al reported that due to visual supports scoliotic patients have compensation mechanisms to provide postural balance.[7] The present study not only confirms the findings of Yamada et al, Byl et al, Chen et al, and Beaulieu et al, but it also suggests that there is a tendency to shift weight to dominant and back side during quiet standing without visual feedback in patients with AIS.[7,15,16] Moreover, the comparison between patients with AIS and healthy adolescents for total BI score showed non-significant differences during eyes open condition, whereas this comparison showed consistent differences during eyes closed and monitor closed conditions. Negrini et al studied on 50 AIS subjects and 20 healthy subjects using stabilometer. They found similar results between the groups when visual feedback was supported. However, postural sways of AIS were greater than healthy group when visual somatosensorial systems were changed. Higher results of BI score help in identifying the visual compensation mechanisms in patients with AIS. It also suggests the presence of a balance control problem in AIS population.[17] Stokes raised the hypothesis in AIS which is caused a lateral displacement from the normal frontal axis of the body.[18]

Kuo et al stated that dynamic balance control of patients with AIS is particularly disruptive under visual deprivation with increasing proximal muscle activities for compensation.[19] Similarly, our subjects also revealed more weight distribution to their dominant extremity with higher balance index score on stabilometer. Thus, we assumed that lateral displacement to dominant side can be associated to an adaptive postural control in patients with AIS.

Gauchard et al underlined that location and type of curve were important factors for postural sway in AIS population.[10] They noted less postural sways in patients with double major curves. Our observations were in agreement with Gauchard et al that is reasonable to assume the similarities in BI score between groups can be more tendency of double major curves which can compensate postural control in patients with AIS.

However, as a limitation of our study, lack of homogenity in curve types in our AIS group did not allow us to analyze the effect of curve type on stabilometer parameters. The results of this study was limited due to the possible measurement error that may be found in stabilometer about pressure platform. Arrangement to 3 PSI is very difficult practice to expose static postural oscillations for all subjects. This could be the reason of similarities for mean BI scores between patients with AIS and healthy adolescents. In addition, patients have not severe curves and Cobb angles which can be an effect on static postural balance.

Within the limitations imposed by the nature of our study, the importance of this research was that similar postural sways in AIS population and healthy adolescents might be a behavioural adaptation pattern in patients with AIS due to their curve progression. Accompanying with the current literature, patients with AIS have more postural sways than healthy adolescents under the lack of visual biofeedback conditions. Patients with AIS may have a tendency to use their visual compensations to provide their static postural control. Therefore, we suggest that the assessment of postural sway is valuable to follow up process in patients with AIS.

This study addressed the assessment in postural sway alterations in patients with AIS. These assessments can be compared with healthy adolescents to help understanding the mechanism of postural instability in patients with AIS during screening process. Our study demonstrated that patients with AIS were less stable and had more oscillations than healthy adolescents when visual feedback was removed. We suggest that there is a possibility of adaptational postural behaviour in patients with AIS compensated with visual feedback system during static postural control. This strengthened the assessment of alterations in postural sway during treatment process in patients with AIS. In addition, it might be related to sensorimotor problems and be masked according to severity and localization of curve. Further research is needed to emphasize postural sway adaptations in patients with AIS.

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