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EVALUATION OF POSTURAL STABILITY IN FEMALE PATIENTS WITH STRUCTURAL SCOLIOSIS

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Abstract

Introduction: Structural scoliosis is a twisting deformity in the curve of vertebral column to the lateral side with simultaneous rotation of the vertebrae, which occurs during the growing years from 10 years to the puberty. **Aim of the study:** Studies investigating balance problems specific to scoliotic patients showed that those patients reveal variable balance abnormalities. In this study we evaluated the difference in postural stability responses between female patients (students, office workers and shish weapon players) with structural scoliosis and normal subjects. **Materials and Methods:** Sixty subjects participated in this study. Thirty female patients with structural scoliosis with a mean age of 19.5 (± 3.26) years, with Cobb's angle ranged from 20° to 40° in the major curves, and thirty healthy female subjects with a mean age of 19.36 (± 2.41) years. Postural stability of both groups was evaluated by the Biodex Stability System. **Results:** There was no significant difference between both groups in dynamic balance test. **Conclusion:** As there was no significant difference between both groups in balance response, it is not recommended to add balance training as an extra physical therapy program for adolescent idiopathic scoliosis (AIS) female patients.

Key words: Structural Scoliosis, Postural Stability, Balance abnormalities Students, Office workers.

Introduction

Scoliosis is a lateral deviation of the normal vertical lines of the spine greater than 10 degrees (Lenssinck et al., 2005). It is tow types: Non - Structural scoliosis is mild, non progressive and fully correctable by ipsilateral bending and Structural scoliosis is moderate or severe with vertebral morphological changes which include wedging and rotation (Cassar-Pullicino and Eisenstein, 2002).

The idiopathic scoliosis accounting for 80% of all cases of structural scoliosis, usually (95%) involving adolescent girls and producing a right-sided curve with apex at T7 on T8, with no clear underlying cause. Adolescent idiopathic scoliosis is found between 10 years of age and skeletal maturity (Lenssinck et al., 2005).

Postural stability or balance is defined as the ability to maintain equilibrium by keeping or returning center of body mass within the base of support (Shaffer and Harrison, 2007). It is two types:

- Static balance refers to ability to control, maintain, and regain the center of gravity within the base of support with the subject still and not subjected to outside perturbations
- Dynamic Balance is the ability to control, maintain, and regain the center of gravity within the base of support in response to outside perturbations or voluntary movements (Kinzey and Armstrong, 1998).

Postural control organizes the orientation and equilibrium of the body during upright stand and is essential to successful performance of daily movements and activities (Lafond et al., 2004)

The idiopathic scoliosis patients are poor in postural control, generally produced higher sway area, lateral sway, sagital sway, and sway radius than normal subjects (Wang et al, 1998).

Dysfunction in various equilibrium factors has been found to be associated with adolescent idiopathic scoliosis. Some investigators found significantly poor postural control in patients with AIS compared with normal children in all of their testing situations. They concluded that their results indirectly indicated the possibility of a postural disequilibrium as a contributory causative factor. Others reported that, subjects with idiopathic scoliosis had difficult in passing the sensory-challenged balance tests but they performed as well as if not better than controls on the simple static balance tests (Sahlstrand, 1978).

Adler et al., (1986) concluded that, subjects with idiopathic scoliosis (IS) had reduced body sway compared with normal subjects across simple and complex balance tests. However, this difference was only significantly different than controls when predictable anterior-posterior oscillations were generated from the movement of the support surface (eyes opened or closed). Furthermore, subjects with progressive curves performed the balance tests with significantly less body sway than those with non-progressive curves. Thus, those subjects with IS demonstrated more well adapted balance reactions than age-matched controls.

Aim of work

To evaluate the postural control in female with structural scoliosis compared to the normal subjects.

Materials and methods

This study was conducted in the Laboratory of Balance in Faculty of Physical Therapy, Cairo University to assess the dynamic balance and dynamic limits of stability in female patients with AIS.

Subjects:

Participants were identified and recruited over 9-month period.

Two groups of subjects with age ranged from 10-20 years old were participated in the present study.

The first group is the control group (A) which included 30 healthy normal female subjects. The second group is experimental group (B) which included 30 female patients with idiopathic structural scoliosis; each patient in the involved group was referred from the orthopedic surgeon with Cobb's angle ranged from (20^o to 40^o).

Inclusion Criteria:

- Age between (10-20).
- Average Cobb's angle was varied between 20^o to 40^o
- Female patients (students, office workers and shish weapon players).

Exclusion Criteria:

- History of previous back surgery.
- Neurologic deficit.
- Current lower extremity symptoms.
- Symptoms of vertigo or dizziness.
- No other disorders in the vertebral column (disc prolapse, spondylosis, and fracture).

Instrumentation:

Biodex Stability System

Biodex stability system (Biodex Medical Systems Inc, Shirley, NY, USA) is used to measure dynamic balance. It utilizes a dynamic multiaxial platform, which can be set at variable degrees of instability. The system is interfaced with computer software monitored through the control panel screen and is supplied with Epson printer to print the test results (Fig. 1). Biodex Stability system showed fair within day test retest reliability for AP stability index (intraclass correlation coefficient (ICC) =0.71) and ML stability index (ICC = 0.73). The time of the test and stability level was the same as that used in the current study (Rowe et al., 1999). Lephart et al. (1995) proved that there is high reliability for dominant single limb standing (ICC = 0.95) and fair reliability for non dominant single limb standing (ICC = 0.78).

Fig. (1) Biodex Stability System

The Foot Platform

The foot platform allows for approximately 20 degrees deflection from horizontal in all directions. Platform diameter is 21.5 inches. Stability is provided by 8 metal springs located at the perimeter of the foot platform. Each spring has an uncompressed length of 13.97 cm, an outside diameter of 3, 11 cm, a wire diameter of 0, 24 cm, The maximum weight capacity of the platform is 300 pounds. The platform has a foot grid for determination of foot position, which is important for centering process of the subject before testing to position the COG nearly over the point of the vertical ground reaction force and also to ensure consistency in each test condition trial. On the surface of the foot platform appear the alphabetic letters from A to P (on the far ends of both sides) with parallel lines joining between them. On the lower most part of the platform surface appear the numbers from 1 to 21 (Rozzi et al., 1999).

Display Control Panel Keys

The display control panel has many keys, which have different functions. On the lowermost left corner of the control panel lays the on / standby key to turn the system on or to standby. From left to right directly under the display screen, the following function keys are present:

1. (Previous screen) key: to return to the screen immediately prior to the current screen.
2. (Next screen) key: to advance to the next logical screen.
3. (Start) key: to activate the foot platform and the clock after the test protocol screens have been completed.
4. (Stop) key: pushing this key at any time during the test returns the foot platform to the fully locked position.
5. (Enter) key: is used to confirm numeric entries, save selected testing parameters, and advance to the next logical screen where applicable.

There are four keys on the right side of the control panel, namely Sl, S2, S3, and S4. Every key has a function, which itself differs according to the screen displayed. The function is indicated in the current screen just beside the key. These functions include selecting from menu, increasing or decreasing parameters or numerical values, and system utilities adjustments etc. (Operation and service manual, Biodex stability system, 1998).

Operating the Stability System

When the system is on, the first displayed screen shows the main menu. It allows the clinician, to choose entering testing, training, or system utilities. Choosing to enter testing shows the next screen, this allows for determining the test parameters as test duration and the stability level chosen. It also records the weight and height of the subjects. The next screen is used to record if both feet, right foot, or left foot test condition is applied. The next screen is used for centering process.

The next screen is the stability test screen. Pushing start key while on this screen unlocks the platform and begins the test. A cursor appears during the test tracing the movement of the platform while the clock counts till the time of the test ends. The next screen shows a menu. Choosing numeric report from this menu allows for showing the numeric report screen. Pressing start while on this screen begins printing the report, which includes the numeric value of the AP stability index, ML stability index, and overall stability index (Operation and service manual, Biodex stability system, 1998).

The outcomes from tests include:

Overall Stability Index: represents the subject's ability to control their balance in all direction.

Anterior/ Posterior Index: represents the subject's ability to control their balance in front to back direction.

Medial/ Lateral Index: represents the subject's ability to control their balance from side to side.

Limits of Stability: the maximum angle one's body can achieve from vertical without losing balance.

Testing procedures:

The first test (Dynamic balance):

1. The subject's weight and height were entered to control screen display located in front of the subject.
2. Position of the support handle and its height were adjusted according to the subject's height and comfort, to grasp it during the initiation of the test, and the subject asked to leave it as the test proceeds.
3. The subject was centered by informing her to stand on both feet, grasp the balance system hard rail.
4. The test duration was set for 30 sec. through 2 levels (1-8).

5. The test duration instructed to try to achieve a centered position on the platform to which is easy to keep the cursor on the visual feedback screen directly in front of the subject.
6. Keeping the cursor in the center of screen grid meant that the platform was kept leveled beneath to subject feet while standing in a comfortable up right position.

The second test: (The limits of stability)

1. Centering the subject again and instructing her to try to shift to move the cursor over the blinking target and back to the center target as quickly and with little deviation as possible.
2. The same process is repeated for each of eight targets.

Then readjusting the apparatus was done and repetition of the same procedures on the scoliotic patients in experiment all group.

Patients or subjects during both tests were with: eye open without hard support both feed striding without foot wear.

Outcome from Tests:

1. Overall Stability Index.
2. Anterior/Posterior (A/P) Index.
3. Medial/Lateral (M/L) Index.
4. Total time in (limits of stability).
5. Overall directional control.

Statistical analysis:

Data obtained from the study was coded and entered using the statistical package SSPS. Descriptive statistics for demographic data and all out come measures were expressed as mean and standard deviation .Comparisons between groups were done using unpaired t- test. P values less than 0.05 were considered statistically significant.

Results

A total of sixty female subjects participated in this study. They were assigned into two groups; the control group (group A) which consisted of 30 normal female subjects with mean age of 19.36 (± 2.41) years, mean weight of 60.53 (± 8.81) kg and mean height of 162.63 (± 5.42) cm.

The experimental group (group B) consisted of 30 females patients with adolescent idiopathic scoliosis with a mean age of 19.5 (± 3.26) years, mean weight of 57.7 (± 10.62) kg and mean height of 162.76 (± 7.20) cm.

Table 1 – Demographic data of both groups:

Variables	Normal (A)	Scoliotic (B)	t-value	p-value
Age	19.36 (±2.41)	19.5 (±3.26)	0.17	0.85 **NS**
Weight	60.53 (±8.81)	57.7 (±10.62)	1.12	0.26 **NS**
Height	162.63 (±5.42)	162.76 (±7.20)	0.08	0.93 **NS**

NS: Non Significant

Using unpaired t-test showed that there was no significant difference between both groups before assessment from their demographic data (Table 1).

Table 2- Comparison between groups after assessment:

Variables	Normal (A)	Scoliotic (B)	t-value	p-value
Overall stability	5.89 (±1.36)	6.39 (±2.32)	1.01	0.31 **NS**
A/P stability	4.59 (±1.13)	5.10 (± 1.75)	1.33	0.18 **NS**
M/L stability	3.65 (±1.32)	4.26 (± 1.69)	1.53	0.13 **NS**
Total time	197.2 (±75.22)	176.1(±73.82)	1.09	0.27 **NS**
Overall directional control	8.7 (±4.82)	9.43 (± 5.82)	0.53	0.59 **NS**

NS: Non Significant

Unpaired t-test was used to detect differences between both groups after assessment. There were no significant differences between normal group and scoliotic group regarding, overall stability ($t = 1.01$, $p = 0.31$), antero posterior stability ($t = 1.33$, $p = 0.18$), mediolateral stability ($t = 1.53$, $p = 0.13$), total time ($t = 1.09$, $p = 0.27$), and overall directional control ($t = 0.53$, $p = 0.59$) (Table 2).

Discussion

This study was conducted to evaluate postural stability in scoliotic female patients compared to normal subjects. Thirty healthy subjects (group A) and thirty female patients (Group B) , were participated in this study, aged from 10 to 20 years old. They were assessed by the Biodex stability system (Mattacola, et al., 2002), in the form of stability index (overall, antero-posterior, and medio-lateral) and the dynamic limits of stability (overall direction control, and the time spent to complete the test).

Patients in the experimental group were diagnosed as moderate to severe idiopathic structural scoliosis with the major curve ranged from 20° to 40° Cobb's angle. They were referred from orthopedic surgeon.

A. Test of Dynamic Balance:

1- Overall stability index:

It has been revealed from statistical analysis that there was no significance difference between the scoliotic and normal subjects in the record of the overall stability index, and this result has been supported by Cassar- Pullicino and Eisenstein (2002), who stated that, the most recent prospective studies with scoliosis have shown a lower incidence of brainstem and cord abnormalities than previously suggested. So it is difficult to say that the scoliotic patients have shown abnormal balance.

Sahlstrand et al., (1978) investigated balance problems specific to scoliotic patients showed that those patients revealed variable balance responses, in which balance response in patients with idiopathic scoliosis comparing them with age-matched controls showed that subjects with IS had similar simple static balance responses when the somatosensory system was stable (with or without vision or head turning).

On the contrary, Adler et al, (1986) concluded that subjects with idiopathic scoliosis had reduced body sway compared with normal subjects across simple and complex balance tests. However, this difference was only significant than controls when predictable anteroposterior oscillations were generated from the movement of the support surface (eyes opened or closed). Furthermore, subjects with progressive curves performed the balance tests with significantly less body sway than those with non-progressive curves. Thus, those subjects were demonstrated more well adapted balance reactions than age-matched controls. This would explain our result, as there were no significant difference in the balance between the experimental group and the control group, as we select our patients with Cobb's angle 20 to 40 degrees which were considered as a relatively progressive, may be because of the compensation which happened to correct the deviation of the trunk.

Dysfunction of various equilibrium factors has been found to be associated with adolescent idiopathic scoliosis. Some authors found significantly poorer postural control in patients with AIS compared with normal children in all of their testing situations. They concluded that their results indirectly indicate the possibility of a postural disequilibrium as a contributory causative factor, and also, subjects with idiopathic scoliosis had difficulty passing the sensory-challenged balance tests but they performed as well as, if not better than, controls on the simple static balance tests (Sahlstrand et al., 1978). But we should not generalized this result on the all degrees of the idiopathic scoliosis.

2- Anteroposterior (A/P) Stability index:

Anteroposterior stability index represents the standard deviation of platform displacement in degrees from level for motion in the sagittal plane (Operation and service manual, Biodex Stability System, 1998). Concerning the A/P stability index we noticed that there was no difference between normal and scoliotic subjects.

The scoliotic patients were selected with Cobb's angle ranges from 20° to 40° for the major curves, and it's generally accepted that the spine does not require surgical correction because such curves do not represents a threats to life or limbs and seldom are associated with an unsightly trunk or chest deformity (Casser – Pullicino, 2002).

These cases would not have the hypokyphosis in the thoracic region which will disturb the A/P stability index, as (Figueiredo and James, 1987) stated that, increased anterior vertebral height at the apex is associated with wedging posteriorly in the vertebral end plate and disc, producing hypokyphosis (> 20°) or a lordosis (> 0°), were the normal kyphosis should be between 20° and 45°.

On the contrary, Robertson (2005) stated that balance is the single most important factor underlying movement strategies with the closed kinetic chain and is defined as the ability to maintain the body's center of mass over its base of support. Good balance exists because multiple systems interact flawlessly and automatically, providing accurate and exact information to our nervous system and this information would not be accurate with abnormal spinal curve as seen in the scoliotic patient either in frontal or sagital plane.

3- Mediolateral (M/L) stability index:

Mediolateral stability index represents the standard deviation of platform displacement in degrees from level of motion in the frontal plane (operation and service manual, Biodex Stability System, 1998).

Concerning the (M/L) stability index, we noticed that there was no significant difference between normal and scoliotic subjects.

Our results in the M/L stability index were supported by (Panzer et al, 1995), who observed that the mean center of gravity adjustment in normal subject was less in mediolateral direction than in anteroposterior direction, and because the base of support of the platform in the mediolateral direction was more able to be controlled than in anteroposterior direction through widening the space between both feet, as observed also in this study. So the patients or normal subjects can easily control the mediolarteral direction to be balanced.

On the contrary, Sahlstrand at al. (1978) stated that this function in various equilibrium factors has been found to be associated with adolescent idiopathic scoliosis. Some authors found significantly poor postural control in patients with AIS compared with normal children in all of their testing situations.

B. Test for the Dynamic limits of stability:

This test includes other two subtests, the limits of stability test and the directional control test. The limits of stability means the maximum angle one's body can achieve from vertical position without losing balance, and direction control indicative of motor control skills, represented as percentage of theoretical excursion value. 100% equals to perfect control (Mattacola, et al, 2002).

In our study both tests revealed no significant difference between both groups (normal and scoliotic groups).

These results were supported by (Cassar-Pullicino and Eisenstein, 2002) who stated that there is no imbalance in scoliotic subjected due to normal brainstem in which if there is an abnormalities ,would affect the balance of the scoliotic patient.

The previous studies were contradicted by (Byl et al, 1997) who, in another study investigating balance problems specific to scoliotic patients, showed variable balance abnormalities, specially that with complex sensory challenged balance tasks when the somatosensory system was challenged by an unstable position of the feet particularly when the eyes where closed ,and also stated that patients with moderate to severe idiopathic scoliosis may have some predicative processing dysfunction, and balance problem from spinal asymmetry, which is still unclear. As Byle stated before as his study had been made with closed eye ,which would affect the balance greatly ,but in the current study ,our test were with open eye.

There is another study which supports our results with Adler et al., (1986) who reported that subjects with idiopathic scoliosis had reduced body sway compared with normal subjects. Their findings were similar to what was observed in this study because none of the balance conditions in the Adler's study challenged medial-lateral stability. Moreover, their subjects were demonstrating a resistance to movement because they might meet their limits of stability and lose control similar to the protective rigidity observed in a patient with vertigo who avoids movement to protect himself against becoming symptomatic.

These findings were also, contradicted by Sahlstrand et al., (1978) findings, where the AIS patients had a significantly poor postural control compared with the healthy children of the same age in all the testing situations. The difference was most pronounced in tests in which the proprioceptive functions were most important for maintaining the postural equilibrium. As well as Chen et al., (1998) findings contradict our results and postulate that AIS subjects produce higher sway area, lateral sway and sagittal sway than normal subjects but their gait pattern is similar to that of normal subjects.

Nault et al., (2002) also conducted that AIS subjects characterized by a decrease in standing stability. This may be due to spinal deformity which does not only modify the shape of the trunk, but also changes the relations between body segments affecting posture in scoliotic subjects. These postural adaptations to the scoliotic curve could be linked in part to increased body sway in upright standing.

Conclusion

It is concluded that there is no defect of postural stability in female with structural scoliosis compared to healthy subjects, either in measuring the dynamic balance for A/P, M/L and overall stability index, or measuring the dynamic limits of stability for the overall direction control or the time to complete this test.

This is due to the low severity of the Cobb's angle taken in the study, as the trunk deformity will increase with high severity or great Cobb's angle, especially beyond 40°, which also will disturb the response of the dynamic balance test. So the information gained in this study might be useful to save the effort from the patient and therapist, and avoid extra physical therapy program of balance training for the patients with AIS.

Recommendations

- Further studies are needed to correlate type, severity and progression of scoliosis relative to measured balance dysfunction.
- Further studies are needed for a thoroughly evaluation of dynamic balance for AIS subjects at different stability levels for different length trials while varying the visual, sensory or vestibular input of balance.
- Future work is needed to make an analysis of lumbar spine motion with electromyography during dynamic balance testing to increase the understanding about dynamic postural compensations in AIS patients.
- Further studies are needed to examine the dynamic balance measures among different age groups, different history of injury and among athletes in various sports

References

1. Adler N, Bleck EE and Rinsky LA (1986): Balance reaction and eye-hand co-ordination in idiopathic scoliosis. J. Orthop Res; 4 (I): 102-107.
2. Byl N, Holland S, Jurek A, et al. (1997): Postural imbalance and vibratory sensitivity in patient with idiopathic scoliosis: implications for treatment. JOSPT; 26 (2): 60-68.
3. Cassar-Pullicino VN and Eisenstein SM (2002): Imaging in Scoliosis, What, why and How? Clinical Radiology; 57: 543-562.
4. Chen PQ, Wang JL, Tsuang YH andLiao TL (1998): Huang PI. Hang YS. The postural stability control and gait pattern of idiopathic scoliosis adolescents. Clin Biomech; 13(Suppl 1):S52-S58.

5. Figueinedo UM and James JIP (1987): Juvenile idiopathic Scoliosis .J Bone Joint surg; 63 B: 61- 66.
6. Kinzey SJ and Armstrong CW (1998): The reliability of the star- excursion test in assessing dynamic balance. JOSPT; 27: 356-360.
7. Lafond D, Corriveau H and Prince F (2004): Postural control mechanisms during quite standing in patients with diabetic sensory neuoropathy. Diabetes Care; 27: 173-168.
8. Lenssinck MLB, Frijlink AC, Berger MY, et al (2005): Effect of bracing and other conservative interventions in the treatment of idiopathic scoliosis in adolescent: a systematic review of clinical trials. Phys. Ther; 85: 1329-1339.
9. Mattacola C, Perrin D, Gansueder B, Cieck J, and Saliba E (2002): Strength, functional outcomes and postural stability after anterior cruciate ligament reconstruction. Journal of Athletic training; 37 (3): 262-268.
10. Nault ML, Allard P, Hinse S, Le Blanc R, Caron O, Labelle H et al (2002): Relations between standing stability and body posture parameters in adolescent idiopathic scoliosis. Spine; 27:1911-7.
11. Operation and Service Manual Biodex Stability System (1998): Biodex Medical Systems Inc., Shirley, NY, USA.
12. Panzer VP, Bandinell S and Fiallett M (1995): Biomechanical assessment of quiet standing and changes associated with aging. Archphys Med Rehabil; 76: 151-15.
13. Rowe A , Wright S, Nyland J, Caborn DNM and Kling R (1999): Effect of two hour of cheer leading practice on dynamic postural stability, knee laxity, and hamstring extensibility. JPSPT; 8: 455-462.
14. Rozzi I, Lephart S, Sterner R and Kuligowski L (1999):" Balance training for person with functional unstable ankles. JOST; 29: 478-487.
15. Sahlstrand T, Petruso N and Nachemson A (1978): Postural equilibrium in adolescent idiopathic scoliosis. Acta Orthop Scand; 49 (4): 354-365.
16. Shaffer S and Harrison A (2007): Aging of the somatosensory system: A translation perspective. Physical Therapy; 87(2):194-207.
17. Wang JL, Issuing Y, Huang P and Hangy (1998): The Postural stability (control) and gait pattern of idiopathic (scoliosis) adolescents. Clinical Biomechanics; 13 (1): 52-58 .