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Isokinetic Imbalance of Hip Abductor/Adductor Muscles in Adolescent Idiopathic Scoliosis

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Abstract

Background: *Adolescent idiopathic scoliosis (AIS) is a progressive growth disease that affects spine biomechanics, and left-right trunk symmetry, however its effect on lower limb muscles strength remains unclear.*

Purpose: *The aims of this study were to compare the isokinetic strength for hip abductor and adductor muscles in AIS with that of healthy individuals, and also to detect the effect of scoliosis location and curve direction on hip abductor and adductor strength.*

Subjects: *this study was conducted on 44 patients with AIS and 23 controls. All patients were selected having structural double curve scoliosis ranged between 20 to 50 degrees Cobb's angle.*

Methods: *AIS patients were divided according to the direction of the primary curve into two groups; right and left scoliosis. Isokinetic torques of the hip abductor and adductor muscles were assessed in both groups of patient and compared to the control one.*

Results: *There was a significant increase in peak torque values of left hip abductor muscles ($p < 0.05$) in right scoliosis group. As for left scoliosis group, there was a significant increase in peak torque values of the right hip abductor muscles ($p < 0.05$). There was no significant differences between the control and AIS groups for hip adductor muscles ($p>0.05$).*

Conclusion: *Adolescent idiopathic scoliosis causes hip abductor and adductor muscle imbalance. Consequently, assessment and rehabilitation of idiopathic scoliosis should include restoring proper muscle balance of hip abductor and adductor muscles regarding the scoliosis curve direction.*

Keywords: *Idiopathic scoliosis, hip muscles, isokinetic, torque.*

Introduction

Idiopathic scoliosis (IS) is one of the most common constitutive deformities of the spine that develops in children and adolescents, with classifications based on age at onset (Weinstein et al, 2008). The reported prevalence of severe curves in girls is more common than in boys(Roach, 1999).Idiopathic scoliosis is a three dimensionalmal-alignment of the vertebral column with subsequent pelvic compensatory mechanisms to maintain upright position and also to draw up health-related quality of life in patients with adolescent idiopathic scoliosis (AIS) (Bao et al., 2014).In structural idiopathic scoliosis, the body asymmetries involve the pelvis and the lower limbs (Kotwicki et al., 2008);however there is a deficiency of studies documenting relation of lower limbs asymmetry to the curve direction and location of scoliosis.

Structural changes in the scoliotic spine affect related muscles, fascia, and other anatomical structures. Hopf et al. (1998) found that the presence of idiopathic scoliosis affects electromyography (EMG) activities of the hip abductors and found that the patients had asymmetrical biomechanical condition when compared to normal subjects with increased activity of the gluteus medius muscles at the concave side of scoliotic curvatures. Moreover, patients with scoliosis showed disturbance in the postural controlthat may be linked postural muscles involved, such as abductor-adductor hip muscles in the medio-lateral direction (Silferi et al., 2004).

Many studies have shown that the biomechanical functioning and hip muscles activity are affected by scoliosis; however there is a lack in the literature that has evaluated objectively the isokinetic strength of hip abductor and adductor muscles. For a better understanding hip muscles strength which are responsible for pelvic stability and force transmission from the lower extremities to the spine during standing and ambulatory activity, it may prove informative to compare the isokinetic strength of hip abductor and adductor muscles of healthy subjects with that of patients with scoliosis, and the effect of scoliosis curve location on their strength. It is hoped that this study will help all professionals to effectively develop and construct comprehensive rehabilitation programs for AIS cases. The corner stone of these programs might be regaining the muscle balance of the major groups around the pelvis. Therefore, the purposes of our study were to compare the isokinetic strength for hip abductor and adductor muscles in AIS with that of healthy individuals, and also to detect the effect of scoliosis location and curve direction on hip abductor and adductor strength.

Materials and Methods

Participants

This study included a total of 67 adolescents from 10 to 18 years old. Forty-four had adolescent idiopathic scoliosis (AIS). Thirty-six were girls. Their Cobb's angle was from ≥ 20 to 50 degrees, whereas patient with an immature skeleton and scoliosis of greater than 25 to 30 degrees is at risk for progression (Hresko, 2013).Twenty-three volunteers from a local school were chosen as healthy controls (group A). Their age, sex, weight and height were relatively similar to the scoliotic group and they had no backache or history of structure deformities. Exclusion criteria were underlying neurological deficit, history of spine injury, brain injury, poliomyelitis, cerebral palsy, congenital or acquired bone deformities and spine deformities. Table 1 presents the demographic data of the participants of both groups. The research was approved by the ethics committee of the Faculty of Physical Therapy, Cairo University.

The forty-four patients with AIS enrolled in this study had double curves, the structural curve classified as thoracic (apex is between T2-T11), and thoracolumbar (apex is between T12-L1). Patients with idiopathic scoliosis characterized by a primary right curve scoliosis (RC) were defined as group B, and those with a primary left curve (LC) were defined as group C. All participants were right leg-dominant. Leg dominance was demonstrated by the preferred kicking leg.

At the first evaluation, the participants and their parents received a detailed explanation about this study. All participants provided informed consent with agreement by their parents before their participation. The subjects were well-informed about the testing procedure, and were educated to familiarize with the isokinetic hip abduction and adduction exercises through sub-maximal exercises were performed.

Instrumentation

A Biodex 3 Multi-joint Testing and Rehabilitation System (Biodex Medical System, Shirley, NY, USA) was used to record muscle torque in each participant. Torque values were gravity-adjusted. Measures of torque and angular velocity, using a variety ofisokinetic dynamometers, have been found to beboth mechanically reliable and valid (Pincivero et al., 1997; Drouinet al., 2004).

Procedures

Participants executed a 10 min of stretching exercises for the hip abductor and adductor muscles prior to entering the laboratory and collecting hip strength measures. Stretching exercise done for 10 min (10 sec hold stretch/10 sec relax). Stretching is used as a technique to promote better performance of concentric isokinetic torque (Abdel-aziem and Mohammad, 2012), and reduce the risk of injury (Garrett, 1990) in the clinical setting. For all subjects, the testing limb was conducted in a randomized order to prevent dependent ordering effect. Rest periods of 10 min were given between the tests of each muscle group. Throughout all testing procedures, participants were verbally encouraged to perform maximal contractions through the range of motion (ROM) of hip abduction/adduction which was 65° (recorded from 20° adduction to 45°abduction). Participants performed isokinetic concentric contraction of hip muscles at angular velocity of 90°/s as previously recommended in the literature (Burnett et al., 1990; Dvir, 1995), whereas speeds faster than 120°/second cannot be tolerated by the AIS (Tsai et al., 2010).

For testing hip adductors and abductors, the subject was positioned in the standing position facing away from the dynamometer with the axis of the dynamometer aligned with the anterior superior iliac spine (Mohammad et al., 2014). According to Tsai et al. (2010), the actual test consisted of three repetitions, and the average of these repetitions for each exercise was used for statistical analysis. The outcome parameter was the peak torque (expressed in Nm) which was normalized to the participants' body weight (expressed in Nm/kg) in an effort to reduce inter-subject variability in raw scores of quantitative muscle tests. All test trials were conducted by a single tester to limit potential inter-rater test error.

Statistical analysis

Data were analyzed using SPSS (version 20.0 for Windows; SPSS Inc, Chicago, IL). A mixed design multivariate analysis of variance (ANOVA) was conducted to compare muscle strength of the right and left hip adductor and abductor muscles in normal versus participants with scoliosis. In case the *F* ratio was significant, the differences between PT/BW were examined using the Tukey test. The level of significance was set at $p < 0.05$ for all statistical tests.

Results

There were no statistically significant differences in gender, age, or body weight and height in-groups A, B and C (Table 1).Peak torque values for the hip adductor and abductor muscle groups for all subjects are presented in Table 2.For group A, the statistical analysis revealed that there was no significant difference ($p > 0.05$) in PT/BW between right and left sides neither for hip abductors nor for hip adductors. There was a significant difference between the control and scoliosis groups for the hip abductors muscles ($p < 0.05$).

A significant main effect was found for the curve direction on the hip abductors of both limbs (right and left) (p < 0.05). There was a significant increase in peak torque values of left hip abductor muscles (p< 0.05) in group B. As for group C, there was a significant increase in peak torque values of the right hip abductor muscles (p < 0.05). On the other hand, there was no significant difference inpeak torque valuesof hip adductor muscles (p > 0.05) in all groups.

Table 1. Demographic data for healthy and idiopathic scoliosis groups.

Groups	Group A *n*=23	Group B *n*=28	Group C *n*=16	*p* value
Gender (male/female)*	3/20	4/24	4/12	0.57
Age (years)†	15.65 ± 2.37	15.50 ± 2.88	16.25 ± 1.58	0.87
Height (cm)†	156.57 ± 6.75	155.17 ± 9.09	156.75 ± 7.47	0.36
Weight (kg)†	52.00 ± 11.74	54.83 ± 14.63	54.31 ± 14.43	0.48

Values are expressed as mean±SD; *: Compared by chi-Square test; †: Compared by ANOVA.

Table 2. The mean values of peak torque/body (±SD) for the hip muscles for the tested groups.

Groups	Position	Right side		Left side	
		Abductors*	Adductors	Abductors*	Adductors
Group A	-	96.72 ± 11.08	74.80 ±13.56	95.86 ± 18.77	76.03 ± 15.12
Group B	Thoracic	50.57 ± 13.01	67.42± 12.05	58.09± 17.24	65.52± 12.66
	Thoracolumbar	82.86 ± 12.09	69.30± 15.88	92.61± 18.33	68.53 ± 15.88
Group C	Thoracic	90.17± 14.05	61.50±16.54	83.77±15.44	71.33± 12.32
	Thoracolumbar	94.60±14.81	50.80 ± 12.33	90.75 ±12.96	56.65±18.44

SD: standard deviation.

* Significant, $p < 0.05$.

Discussion

This study was conducted to compare the isokinetic torques of hip abductor and adductor muscles in AIS with that of healthy individuals, regarding the scoliosis location and curve direction. Clinicians and researchers, who studied the children with idiopathic scoliosis considering their examination and treatment, point to the existence of associated biomechanical disturbances (Tsai et al., 2010; Perkins et al., 2012). The abnormalities within spine and lower limbs have an effect on the progress and persistence of scoliosis (Pingot et al., 2007); therefore their detection is essential for the rehabilitation program. One of the reliable technological advances that improve the evaluation of scoliotic patients is the isokinetic assessment (Blay et al., 2007).

The results of this study demonstrate an impairment of muscle strength within the pelvis. The peak torque values of control group tended to be greater than that of scoliosis groups. This result was found to be in accordance with Blay et al. (2007) who shown that trunk and knee muscles strength for the scoliotic subjects was significantly lower than healthy subjects.

The finding of this study revealed that, the mean PT/BW value of the left hip abductor muscles was significantly higher in group B (right scoliosis) and that of right hip abductor muscles was significantly higher in group C (left scoliosis). A possible explanation for higher muscle activity of contra lateral hip abductors may be the stabilization of the pelvis by preventing pelvic drop. This pelvic obliquity may come from upper or lower origin. Pelvic obliquity of ‘‘upper origin’’may result from asymmetric retraction of the muscles connecting trunk and pelvis, while that results from hip posture asymmetry and induces pelvic mal-positioning, which in turn point up the underlying scoliosis; is known as pelvic obliquity of ‘‘lower origin’’ (Vialle et al. 2013).

Therefore, higher contra lateral hip abductor PT/BW may be to counteract the pelvic obliquity that may be caused, firstly by contra lateral tight lower back muscles (concave side), as the length and tone of the trunk muscles were affected, with those on the concave side tending to be contracted and shortened. This was supported by that showed by Tsai et al. (2010) who found that EMG activities of the thoracic muscle were significantly higher on the concave side than on the convex side during isokinetic exercise in patients with AIS. The second explanation may be the tightness of ipsilateral hip abductors that result in downward pull. The results of the present study are consistent with those of by Winter and Pinto (1986) who reported that the pelvic obliquity can be caused by contractures about the hips, as part of a structural scoliosis. In the same context, Hopf et al. (1998) showed increased EMG activity of gluteus medius muscles at the concave side of scoliotic curvatures

This finding is in contrast to Frischhut et al. (2000), and Moon et al. (2011) who suggested that the muscular imbalance below the pelvis cannot be considered to be a causative factor of pelvic tilt. One likely reason for this discrepancy in the literature may be the studying of pelvic obliquity in different types of scoliosis such as neuromuscular disorders.

However, there was no significant difference in peak torque values of hip adductor muscles in all groups, the PT/BW valueof right hip adductor was higher in group B, and that of left hip adductor was higher in group C. These results was supported by the finding of Kotwicki et al. (2008) who found that no significant difference in the proportion of symmetric/asymmetric hip adduction range between patients with scoliosis and controls and also between right and left hip adduction range of motion of scoliosis in girls with structural scoliosis.

Conclusion

Based on the findings of this investigation, assessing hip adductor and abductor muscles strength is a crucial step in the evaluation of patients with scoliosis. Scoliosis refers to a lateral curvature of the spine and a corresponding rotation of the spine, which involves muscle imbalances, associated not only with those muscles responsible for movement of the spine itself, but also associated with the hip abductor and adductor muscles. Considering the curve direction, disturbances in the pelvic are alead to compensatory changes within the spine and lower limbs. So, restoring proper muscle balance of hip abductor and adductor muscles in patients with scoliosis will help physical therapist to provide better rehabilitation program.

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