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Original Article

Effect of Thoracic Hyper-Kyphosis Posture on Upper Extremity Function of Female Students

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ABSTRACT

Background: Thoracic hyper-kyphosis is one of the most common postural disorders of the spinal column. Decreased strength of spinal extensor muscles and range of motion of joints such as the shoulder is associated with hyper-kyphosis, which can affect the physical function and life of an individual. The f present study aimed to investigate the effect of thoracic hyper-kyphosis on upper extremity function among female students.

Methods: The current cross-sectional study included a population consisting of 226 female students aged 13-18 years old divided into two groups: 113 participants with normal and 113 with abnormal thoracic hyper-kyphosis. The kyphosis angle was measured using a flexible ruler, and the Y test, Davis test, and disabilities of the arm, shoulder, and hand (DASH) questionnaire were used to measure upper extremity function. Independent t-test and Pearson's correlation were employed for data analysis.

Results: The Davis, Y, and DASH test results showed a significant difference in upper extremity function between subjects with and those without thoracic hyper-kyphosis ($P<0.05$), with the abnormal thoracic hyper-kyphosis group showing poorer function than the normal group. The results also demonstrated a significant relationship between the kyphosis angle and the Davis, Y, and DASH tests ($P<0.05$).

Conclusion: Overall, kyphosis abnormality was found to lead to weak upper extremity function, and an inverse relationship was observed between the kyphosis angle and the Davis test and Y balance test. Moreover, a direct relationship was found between the kyphosis angle and DASH test.

Introduction

Normal body structure, i.e. desirable posture, is one of the most important health indicators of societies which is closely related to the mental and physical health of individuals. A normal and correct body posture is the state of muscle-skeletal balance that includes the minimum amount of muscle stress and tension. If the muscle-skeletal balance of one's body is lost, the individual's posture changes; these variations are known as postural abnormalities [1-3]. One of the most common postural abnormalities of the spinal column is hyper-kyphosis, which is one of the effective factors for future pathology of the upper quarter, covering a range of issues from shoulder pains to vertebral fractures [4]. Researchers have reported a ratio of females to males of 2:1 [5] and prevalence rates for this abnormality of 15.3% among

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children aged 11 years, 38% in individuals aged 20-50 years, and 35% in individuals aged 20-64 years [6].

Research has indicated that factors such as maintaining incorrect body posture for a long period, excessive stress and pressure on the spinal column, and thoracolumbar muscle weakness could be major factors causing increased kyphosis [7]. Hyper-kyphosis leads to impaired respiration, pulmonary function problems such as increased breathlessness, reduced flexibility of muscles such as the pectoralis major and minor and serratus anterior muscles [8, 9]. Decreased strength of spinal extensor muscles and reduced range of motion of joints such as the shoulder are associated with hyper-kyphosis, which can affect the physical function of individuals [10]. Research has further shown that hand function is affected by scapula stability, and the correct position of the scapula is known to increase the efficiency of motion in the upper extremity [11]. In an individual with kyphosis, however, the scapulae are in a protracted posture [12], and scapula protraction caused by kyphosis disrupts the scapula-humeral rhythm [13]. Increased kyphosis in the chest restricts the motion of the scapulae and chest and, as a result, reduces the range of motion of the shoulder joint [14]. Such cases can reduce stability in the upper extremity followed by an impact on function; nevertheless, this issue has not been researched. Because the upper extremity is part of the mobility chain, and considering the changes caused by hyper-kyphosis as well as the prevalence of this disorder among female students, the current research aimed to investigate the relationship between thoracic kyphosis and function among female students.

Methods

The current case control study chose a population of 113 hyper-kyphosis students as the case group and 113 healthy students as the control. Subjects with kyphosis as well as those without disorder were selected from Tehran and Khuzestan provinces. Kyphosis cases were selected from people referring to two corrective exercise centers in the two study cities, and 57 people from Tehran and 56 people from Khuzestan were in each group. Inclusion criteria were age range for both groups as well as an angle of 28-49 for the normal kyphosis (control) group and an angle >49 for the hyper-kyphosis group [15]. Exclusion criteria were scoliosis, a history of surgery in the spinal cord, neuromuscular diseases, vision defects, or vestibular system defects [16]. All participants and their parents signed an informed consent form before participating in this research. The Ethics Committee of the Department of Health and Sport Medicine, Tehran University approved this study (Code: IR.UT.SPORT.REC.1398.058).

Procedures

After participants gave written consent to participate in the research, their heights and weights were measured using a stadiometer. A 60-cm flexible ruler was used to evaluate the kyphosis angle. According to recent studies, the flexible ruler has the accuracy of 0.1 and reliability of 97% [17]. The flexible ruler validity is 72% compared to the Cobb method, with the intra-rater validity of 83% and inter-rater validity of 94% [18]. In this research, the participants were initially asked to take off their upper body clothes, stand naturally and comfortably on a flat surface with bare feet so that their body weight could be divided equally between both legs, and keep the hands free on both sides of the body. The T2 and T12 marker points were indicated using a marker, and the flexible ruler was placed on the spinal column and molded to take the form of the thoracic curve. Afterwards, the ruler without deformation was moved to a sheet of white paper. The two ends of each curve were connected by a line known as L, and a line perpendicular to line L, called line H, was drawn (Figure 1).

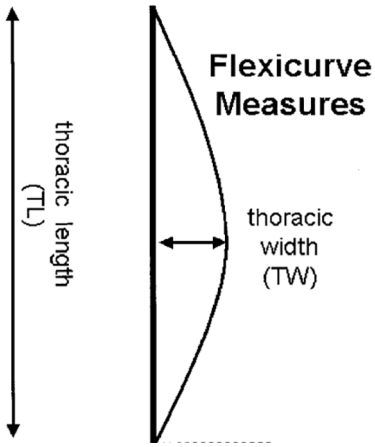

Figure 1: Hyper-kyphosis measurement

After L and H were measured with an mm ruler, their values were placed in the formula ɵ=4 arc tang(2H/L) and the kyphosis angle was calculated [19]. To avoid errors in measuring the kyphosis arch, measurements were repeated three times, and their mean was recorded as the thoracic spinal curve angle of the individual.

Upper Quarter Y-Balance Test

Upper extremity function was evaluated using the Y test developed by Poliski. This test has high validity and intraclass correlation coefficient reliability (ICC: 0.95) [20]. Given that this test has a significant relationship with the length of the hand, each individual's hand length was calculated using the tape meter to perform test and data normalization. For this purpose, the participant was asked to raise the arm to 90 degrees of abduction; then, the distance between the C7 vertebra and the middle finger on the hand was measured using the tape meter. Afterwards, medial reach, superior lateral reach, and inferior lateral reach directions were drawn on the ground using a tape meter at 120-degree angles to each other. Then, the participant was placed at the intersection of the three directions by the non-dominant hand for testing and moved his/her dominant hand for maximum reaching distance immediately in three directions and returned it to the initial position. All participants moved in each direction three times, and the average number obtained for hand length (cm) was divided and then multiplied by 100 for normalization of score [20].

Davis Test

The Davis test is a modified swimming test that was presented by Davis and Dickoff-Hoffman in 1993. This test examines the muscular strength and upper extremity closed kinetic chain and has high validity and reliability (ICC: 0.87). This test is performed as full Swedish swimming for men and modified Swedish swimming for women. In both genders, the back is straight and the hands are positioned 36 inch (or 91.4 cm) from each other and perpendicular to the ground. Subjects bend with one hand at full speed and touch the opposite hand in 15 sec; then, the individual returns to the original position and does the same thing with the opposite hand. Each participant performed the test three times with a 45-second rest period between each trial. The three successful trials of each individual were recorded, and the score was calculated (using the average number of hand touching repeated in 15 sec) by the average number of hand repetitions divided by individual's height (normalized score), and the power score was obtained by multiplying the average touch of the hands by 68% of the participant's weight divided by 15 [21].

Disabilities of the Arm, Shoulder, and Hand (DASH) Questionnaire

The DASH tool contains 38 questions about upper extremity symptoms and function. In this questionnaire, each question is scored using five options ranging from 1 (no difficulty or symptoms) to 5 (disability and highest symptoms). The final score is calculated from the sum of the scores per 100; higher and lower scores suggest more problems and fewer problems, respectively. Given the current research type, 30 questions were used to evaluate self-reported upper extremity function. This questionnaire was validated and translated into Persian by Mousavi et al. Face validity and content validity of the questionnaire were approved by experts, and the reliability of the questionnaire was determined using Cronbach's alpha (83%) [22].

Statistical Method

The Kolmogorov-Smirnov test was used to determine the normality of the data. The independent t-test was employed to compare the Y test, Davis test, and DASH questionnaire scores. Moreover, Pearson's correlation was run to determine the relationship between the kyphosis angle and the scores obtained from the Y balance, Davis test, and DASH questionnaire. Significance level in this research was considered equal to alpha<0.05.

Results

The demographic information of both groups is summarized in Table 1. Results of the independent t-test showed no significant difference among individuals in height or age (Table 1).

The thoracic kyphosis angle in the kyphosis group was almost 16 degrees greater than that of the normal group. As shown in Table 2, the Davis test, Davis normal test, and Davis power test in the kyphosis group (mean±standard deviation: 20.47±4.78, 0.13±0.04, 13.92±3.25) were considerably (P=0.0001) less than those without kyphosis (23.39±3.90, 0.14±0.02, 15.90±2.65). Composite Y was considerably less in the kyphosis group (57.04±8.83) than in the control group (59.57±9.84) (P=0.04). The DASH test was considerably lower in those without kyphosis (40.81±80.06) than in the kyphotic ones (44.76±10.30) (P=0.002). The DASH2 test was considerably lower in those without kyphosis (9.01±6.72) than in kyphotic persons (12.30±8.58) (P=0.002).

Correlations of the kyphosis angle with the tests were as follows: Davis (P=0.000, r=-0.358), Davis normal

Table 1: Demographic data for the two groups

Variable	Kyphosis group N=113	Control group N=113	P value	t	Mean difference	95% Confidence interval of the difference	
						Lower	Upper
Age (years)	14.90±1.67	14.76±1.47	0.528	0.632	0.13274	-0.28102	0.54650
Height (cm)	158.10±12.31	157.15±8.32	0.499	0.677	0.94690	-1.80817	3.70198
Weight (kg)	56.60±16.22	50.52±10.71	0.001	3.320	6.07345	2.46813	9.67877
BMI	21.86±4.46	20.39±3.68	0.008				
Thoracic curvature (degrees)	56.60±6.75	40.49±5.09	0.000				

Body Mass Index (BMI)

Table 2: Davis, Davis normal, Davis power, Composite Y, and Disabilities of the Arm, Shoulder, and Hand (DASH) tests data in kyphosis and healthy groups

Variable	Kyphosis group N=113	Control group N=113	P value
Davis	20.47±4.78	23.39±3.90	0.0001
Davis Normal	0.13±0.04	0.14±0.02	0.0001
Davis POWER	13.92±3.25	15.90±2.65	0.0001
Y internal	0.70±0.09	0.73±0.10	0.079
Y exterior upper	0.43±0.12	0.46±0.12	0.026
Y external lower	0.57±0.13	0.58±0.14	0.447
Composite Y	57.04±8.83	59.57±9.84	0.04
DASH	44.76±10.30	40.81±8.06	0.002
DASH2	12.30±8.58	9.01±6.72	0.002

Disabilities of The Arm, Shoulder and Hand (DASH)

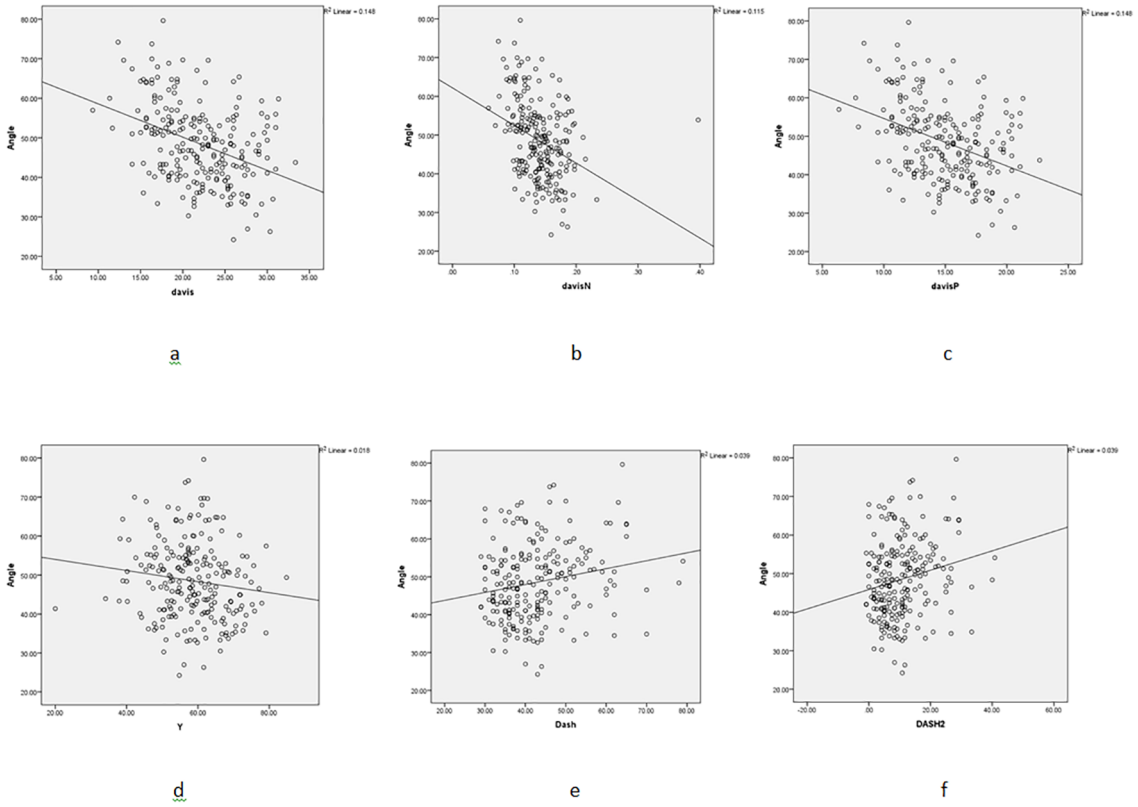

Figure 2: Relationship between kyphosis angle and functional measurement. a: Davis test, b: Normal score of Davis test, c: Power score of Davis test; d: Upper extremity Y test, e: Dash questioner score

(P=0.000, r=-0.339), Davis power (P=0.000, r=-0.385), Composite Y (P=0.045, r=-0.133), DASH (P=0.003, r=0.17), DASH2 (P=0.003, r=0.197) (Figure 2).

Discussion

The data in the current research showed that kyphosis abnormality and upper extremity postural dysfunction can cause defects in higher functions. As a result, a significant difference was found between upper extremity function without kyphosis and those in the kyphotic group, and a dysfunction was found among the kyphotic participants.

As hypothesized in the present study, those with greater kyphosis angles did not perform well on the Davis and Y balance tests, and DASH questionnaire scores showed that insufficient upper extremity function was higher in the kyphotic participants. These findings are consistent with previous research. Antonelli-Incalzi et al. [23] revealed a strong association between kyphosis and mobility performance in women compared to men aged 65 years and older. Increased kyphosis is also associated with back extensor muscle weakness [24]. Suri et al. [25] used the Short Physical Performance Battery (SPPB) score as an index to measure mobility performance in kyphotic participants and concluded that disability in mobility performance could be related to back muscle strength. Therefore, the decreased strength of the back extensor muscles may be associated with dysfunction in the tests as well as greater kyphosis angle. The scapula plays an important role in shoulder function, which includes upper extremity muscle stability, connection to the arm and its motion to provide precise kinematics of the shoulder joint, force distribution from the joint center to the hand as a result of providing optimal mobility stability, and inducing a motion with the aim of maximizing the external rotation of arm. Accordingly, the most effective position and motion of the scapula to achieve the mentioned goals and optimal roles are in scapular retraction, retraction motion, and control protraction, respectively. Hence, the chronic shortening of the serratus anterior, which is a major pattern specified among hyper-kyphosis participants, causes scapular protraction, and reduced scapular retraction will cause anatomical disorder, lack of balance and strength in the muscles, and a poor relationship in the upper extremity mobility chain, because the inability to maintain or achieve the scapular retraction position reduces optimal arm functionality. As a result, individuals will show a reduced ability in performing the functional tests of Davis and Y [12]. The muscles are responsible for shoulder joint stability in 90% of motions made across all plates of the shoulder joint [26]. Rotating muscles are considered as arm stability supports in the glenoid cavity and reduced displacements in the shoulder joint [27]. Thus, a stable base is required to reach the maximum activity of shoulder rotating muscles [28]. This need is met by the scapula's optimal motion, which leads to optimal cavity structure in arm motion. Hence, in the absence of desirable scapular motion, shortening of the superficial muscles is observed, which causes anterior shoulder tilt in the chest, which results in a decrease in the functional score of the Davis and Y tests [29]. Another mechanism that hinders performance in these tests is based on Janda's balance theory. Upper extremity stability is composed of posture without kyphosis, while a decrease in strength causes an inconsistency between the length

and tension of the hand muscle and affects the lower part. According to Janda's theory, there is a movement chain in the upper extremity which begins at the neck and ends at the fingers. All components of this chain should work consistently to achieve proper implementation [30, 31]. Hyper-kyphosis will cause a muscle imbalance in various upper extremity kinetic chains, including small thoracic muscles in the flexor chain, rhomboid muscles in the extensor chain, large thoracic muscles in the anterior chain, and rhomboid muscles and serratus anterior in the posterior chain [32]. Therefore, inappropriate function in this chain will be caused by reduced strength [16]. The relationship between hyper-kyphotic posture and mobility function among the elderly was evaluated by Kado et al. [8], who concluded that greater kyphosis angle could be associated with decreased strength in the upper extremities. The correlation between the kyphosis angle and the Davis test (r=-0.385) indicated that the greater the kyphosis angle was, the lower the Davis score would be.

Moreover, in the correlation between Y balance and kyphosis angle (r=-1.33), the greater the kyphosis angle is, the lower the result of Y balance, strength, and power in the upper extremity muscles will be. A highly positive correlation between kyphosis angle and DASH questionnaire score (r = 0.197) indicates that an increase in the kyphosis angle in kyphotic individuals will increase the score showing the disability level in the upper extremity function of the shoulder.

As a result, considering all the factors that lead to a lack of stability in shoulder joint function and the upper extremity motion chain, such as decreased strength in the shoulder joint rotating muscles as well as a lack of muscle stability in the scapulae and, consequently, weakness in the motion chain that leads to the hands, those with kyphotic posture will face reduced upper extremity function compared to those without kyphosis.

The present research had some limitations. First, only females were studied, which could reduce the external validity of the research. Second, information on pain was not collected from the patients. Pain can affect the functional score that an individual receives on the tests. Third, although the measurement and evaluation method used in the research was effective and reliable, it is expected that future research will evaluate the kyphosis angle by more precise methods, such as X-ray.

Conclusion

Based on the data analysis, it can be concluded that individuals with kyphosis have a disability in the upper extremity and shoulder mobility function compared to those without kyphosis.

Conflict of Interest: None declared.

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