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The Effect of Spine Strengthening Exercises and Posture Training on Functional Thoracic Hyper Kyphosis in Young Individuals

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ABSTRACT

Background & Objective: Hyper- kyphosis negatively affects health status, physical mobility, and quality of life. Corrective exercise interventions are often utilized to manage subjects with thoracic hyper-hypnosis. The purpose of this study was to investigate the effectiveness of multimodal spine strengthening exercises (spinal strengthening, spinal alignment and other such exercises for increased spine mobility) and posture training in young individuals with functional thoracic hyper-kyphosis.

Materials & Methods: 97 young men with hyper-kyphosis abnormality (a kyphosis angle of more than 42 degrees) with a mean age of 23.82±2.96 years, the height of 174.74 ± 7.75 cm, and the weight of 70.36 ± 8.53 kg were selected. The individuals were randomly assigned to experimental and control groups. Experimental group subjects participated in a 12-week progressive corrective exercise program with postural training that was performed 3 sessions per week for one hour, while the control group subjects underwent daily activities during the same period. The kyphosis angle was measured with a flexible ruler. Data was analyzed by ANCOVA.

Results: The findings of the study showed that the multimodal spine strengthening exercise (spinal strengthening, spinal alignment and exercises for increased spine mobility) and postural training had a significant effect on the reduction of the thoracic kyphosis angle in the experimental group ($P \leq 0.05$).

Conclusion: Corrective exercises along with postural training are recommended for the correction of hyper-kyphosis abnormalities in young adult.

Keywords: Kyphosis, Exercise therapy, Postural balance

Introduction

Excessive thoracic curvature of the spinal column (Hyper kyphosis deformity) is one of the most common postural abnormalities and is one of the most important causes of the upper quarter pathology (1-4). Spinal abnormalities in individuals with completed skeletal growth have been reported at an estimated 32% prevalence in adults and a prevalence of 60% in the elderly (5). Hazebroek (1992) reported hyper-kyphosis abnormality with a 15.3% prevalence in 11 year olds and Morris (1992) reported a prevalence of 38% in individuals aged 20 to 50 years and Cutler (1993) declared a hyper-kyphosis abnormality of 35% in 20 to 64 year old individuals (6-8). It has been reported that the degree of normal kyphosis was at 42 degrees for those aged 18 to 28 years in Iran (9). Moreover, the mentioned angle is considered as an anomaly of hyper kyphosis (9). Hyper kyphosis can have a significant negative effect on the health status, physical activity and quality of life of the affected individuals (10, 11). Hyper kyphosis is related to the quick degeneration of the spine. The thoracic disorders are integrated to cervical vertebrae which include cervical lordosis and can lead to Upper Crossed Syndrome (13). In the teenagers who grow quickly abnormal spine flexion prevent the viscera to develop. An extraordinary thoracic kyphosis is accompanied with changed respiratory function (13). Furthermore young adults and teenagers' posture and appearance can be affected by hyper-kyphosis and may consequently affect their health physically and psychologically.This anomaly affects the respiratory function (15) and interferes with the individuals daily activities (11). Hyper-kyphosis increases the biomechanical stresses on the vertebral column (16) and increases the risk of osteoporosis in the spine and the compression fracture of the vertebral column (17). Katzman (2016), in his study entitled Thoracic kyphosis and rate of incident vertebral fractures: the Fracture Intervention Trial reported that an increase in the incident of vertebral fractures increase kyphosis up to 22% for every 10 degrees (18).

Early detection, correct assessment, sufficient cure and rehabilitation, prevention, and suitable active exercise may impede different effect of postural and spinal deformities and prepare an even function to the adolescent organism. Seriously impaired posture in youth people originates of this fact which timely correction of static deformation had not been previously made. It is a providing reason to enhance structural variation in the spine and diseases of internal organs which is led to reduced disability in the middle ages **(19-21)**. There is no standard protocol for kyphosis correction despite its adverse effects on one's health status, physical function, and quality of life **(22)**. Hyper kyphosis abnormality is treated and corrected in a variety of ways, such as: manual therapy **(23)**, postural re-education **(24)**, usage of taping and orthoses **(24)**, and surgical and therapeutic exercises **(25, 26)**. In the meantime, exercise therapy is a common practice and specialists typically manage kyphosis abnormality with the prescription of an exercise program **(27-29)**.

The trunk muscles participate in the spine's movement's controls and stability and the deep and central muscles of the body provide spinal stability in dynamic situations and provide stabilization and control of the intervertebral movements **(30)**. With that said, it seems that the strengthening of the back extensor muscles and the muscles around the spine have a significant effect on the reduction of kyphosis angle. However, to determine the effectiveness of special hyper kyphosis exercises, researchers of a study with 7 randomized and controlled subjects, found exercises that merely emphasize on the increase of muscle strength and local exercises to have relatively little effect on the correction of hyper kyphosis. Moreover, in comparison to different therapy methods, the performance of physical exercises allows individuals to play an active role in the field of health, and if these exercises are done correctly, it can provide many benefits, especially, if the exercises are performed with the aim of increased strength in the back muscles and flexibility of the spine, in combination with exercises for spinal alignment improvement **(22)**. Katzman *et al.* (2017) reported that multimodal spin-strength exercises on men and women over the age of 60 and with more than 40 degrees of kyphosis is effective in correcting the abnormality, and improving one's physical function and quality of life **(29)**. Feng *et al.* (2018) reported in their study "The effect of a corrective functional exercise program on postural thoracic kyphosis in teenagers: a randomized controlled trial" that performed functional exercises (Holistic approach which observes flexibility, strength and proprioception along the length of the spine) solved acute thoracic kyphosis in teenagers (almost 9 degrees). The program of training solved thoracic ROM too; assignment of muscles near the pelvis and the ability to adapt weight loaded on the upper and the lower body **(30)**. Therefore, according to the results of previous research and the idea of Vladimir Junda, the mentioned anomaly in the form of a status chain reaction, has a close relationship with other parts of the body and each individual correction of the anomalies lacks a proper scientific justification, individually and locally **(30)**. Therefore, the design and implementation of corrective exercises (spinal strengthening, spinal alignment and exercises for increased spinal mobility) seem necessary to correct this abnormality **(22)**. In previous studies clear recommendations and standard protocols for kyphosis correction had not been available due to the low number of subjects, the heterogeneity of subjects, the age of subjects, the differences in measurement methods, the invalidity of measuring instruments, and the lack of postural exercises **(29)**. Previous studies had shown that the prevalence of anomalies in Iran was high and particularly increasing amongst young individuals. Therefore, the purpose of this study was to investigate the affectivity of spine strengthening exercises (*spinal strengthening*, *spinal alignment* and *spinal mobility)* with simultaneous posture training in young individuals of functional thoracic hyper-kyphosis.

Materials and Methods

The present quasi-experimental study investigated the effect of multi-modal spinal strength exercise protocols on hyper kyphosis abnormalities in two groups, control and experimental. The ethics code of this study is IR.UT.REC.1395018. The statistical population of the study included non-athlete students aged 18 to 28 years of age at Zanjan universities. The students who had postural kyphosis abnormalities (≥42 degrees) were identified from general physical education classes by research colleagues and introduced to the examiner. After an evaluation of the kyphosis angle, the researcher divided the number of eligible individuals (97 individuals) into two experimental and control groups randomly based on the criteria for entering and leaving the study. The following reasons resulted in the dismissal of individuals from the research sample: pathological symptoms, history of fractures, surgery or joint diseases (especially in the spine), hip or shoulder belt, lower cross syndrome, regular physical activity, championship or membership in sports teams, certain occupational conditions (which exacerbate kyphosis abnormalities and not be able to modify the physical condition in the workplace), reluctance in the participation or continual of the exercises, absence in 2 consecutive exercises sessions and 3 alternate sessions of the 12-week training program and absence at measurement sessions of dependent variables in pre-test or post-test research. After completing the informed consent, the subjects were randomly assigned to one intervention group (selected exercises program) and one control group and then, all of them participated in a pre-test.

A flexible ruler was used to measure the kyphosis angle so that the spinous process of T2 and T12 vertebrae were used as the primary and final points of the kyphosis arcuate arch **(31-34)**. In order to determine the spinous process of T2 vertebrae, the examiner stood behind the subject and asked him to bend his head. In this situation, two prominences are seen at the end of the cervical region, which is the spinous process of the C6 and C7 vertebrae. Then, at the touch of the two prominences, the examiner asks the subject to slowly turn his bent head posteriorly. In such a situation, one of the prominences of the C6 disappears under the hands of the examiner, and only one prominence is touched, which is the spinous process of the C7 vertebrae. Now, with the identification of the spinous process of the C7 vertebrae, it is easy to determine the tufts of the T1 and T2 vertebrae by pinching down and along the spine, respectively. In the present study, after identifying the T2 vertebrae, the initial point of the kyphosis arch was marked with Landmark. The Hoppenfeld method was also used to find the T12 vertebrae, which has been used in many other studies **(35)**.

In this method, the examiner stood behind the subject and asked him to slightly bend his body forward from the waist and reach his hands towards the bed in front of him, while transferring his weight onto his hands. This is done to reduce the activity of the extensor muscles and subsequently allow for an easy evaluation of the spinous process of the spine. In such condition, to reach the spinous process of the T12 vertebrae, the lower edge of the twelfth rib was touched on both sides by the thumb, with both thumbs simultaneously moved upwards and inwards on both sides of the body, until the rib was disappeared underneath the soft tissue. At that time, the midpoint of the line between both thumbs was marked as the spinous process of the T12 vertebrae (the end point of the kyphosis arch) with a Landmark. Finally, after identifying the bone markers required for the measurement of kyphosis in the breast, the subject was asked to stand naturally and comfortably, look forward and place his weight on the same foot (legs to be apart as 10-15 cm and completely naked). 30 seconds was provide to allow the body to reach its natural and comfort state. A flexible ruler was then used on the thoracic kyphosis of the individual to take the shape of the arc. After fixing the flexible ruler on the kyphosis area, the points were marked with a marker in contact with the middle part of the landscapes, and were removed without any change in the form of a flexible ruler and they were removed slowly and carefully from the spine and were placed on a graduated paper. Then, the curvature of the ruler was drawn on paper and the T2 and T12 points were determined. To calculate the kyphosis angle on the obtained shape from the flexible ruler, first, the T2 and T12 points were connected with a straight line and drawn from the deepest linear curvature point to the T2 and T12 lines. These two lines were called L and H, respectively. Their values were calculated with the formula ($\theta = 4$ Arc tang $(2h/l)$) and the kyphosis angle was calculated accordingly **(31-34)**.

At the next step, standard anthropometric and demographic data related to height, weight, and age were collected using stroke and digital scales from all subjects and were recorded on special sheets. Subjects in the control group continued their daily routine without any specific exercises, while the intervention group controlled the selected exercises for 12 weeks (three sessions per week and 60 minutes each session) under the direct supervision of the examiner. At the end of this period, all subjects in the experimental and control group were once again evaluated and the variables were measured at post-test with the same trend at pre-test. The subjects of the participating group were divided into 4 groups of 10 and a group of 7 individuals. During the exercise period, the researcher assured that there was a trainer for each 5 individuals, so that in each of the 5 training groups, one collaborator helped the research in addition to the researcher implementing the exercise protocols. The exercise program consisted of three main sections that included *spinal strengthening*, *spinal alignment* and exercises for increased *spinal mobility*. The program of training designed with more fold musculoskeletal injuries are related to hyper kyphosis, consisting weakness of spinal extensor muscle, reduced spinal mobility and inferior postural alignment. The intensifying component of spine adapted the strengthening exercise with high intensity designed to strengthen spinal extensors and make stable the trunk in neutral alignment.

Exercises gradually progressed in intensity using Thera-Band or weight resistance with low (30%–40%), moderate (50%–60%), and high-intensity (70%–80%) resistance according to perceived exertion until a Borg scale intensity of 4 to 5 was reached.

The movements of this part included: supine transverse abdominal on a roller ($10^{R}\times1^{Set}$) quadruped arm and leg lift ($8^{R}\times2^{Set}$); spine extension in prone trunk lift to neutral ($8^{R}\times2^{Set}$); side-lying thoracic rotation/extension ($8^{R}\times 1^{Set}$) and side-lying hip abduction/external rotation ($8^{R}\times2^{Set}$) (Figure 1-1-1-5). The *spinal alignment* component integrates spinal extensor strength and mobility into practice. The movements of this part include: Marching on roller ($10^{R}\times1^{Set}$), unilateral overhead reaching on roller ($10^{R}\times1^{Set}$), bilateral pull-down supine on roller ($10^{R}\times1^{Set}$), Shoulder flexion/thoracic extension at wall ($10^{R}\times1^{Set}$), wall push-ups ($10^{R}\times1^{Set}$) and single-leg stance ($10^{R}\times1^{Set}$) (Figure 2) **(6-11)**. The *spinal mobility* component is performed with foam rollers and end-range exercises to enhance spinal rotation and extension and decrease the mobility limitations around the anterior shoulders, chest, and spine. Participants lie supine on foam rollers and fulfill side lying and standing end-range thoracic extension and rotation to mobilize the spine during exercise.

The movements included chest and spine stretching supine/roller ($1^{set}\times30$ sec. passive stretching), gluteal stretching ($1^{set}\times30$ sec. passive stretching), supine straight-leg raise ($1^{set}\times30$ sec. passive stretching), prone hip/quadriceps stretch ($1^{set}\times30$ sec. passive stretching), quadruped thoracic extension stretch ($1^{set}\times30$ sec. passive stretching), and Neck/chest stretch standing ($1^{set}\times30$ sec. passive stretching) (Figure 3) **(12-17)**. The intensity of the exercises was increased during the study, with an emphasis on the quality of the movement. The participants maintained the training intensity on the basis of the Borg scale on 4 to 5 (70-80%) perceived pressure. Subjects also received tutorials on postural exercises through audiovisual and feedback that taught them to maintain and improve spinal cord neutralization during training sessions. The subjects were trained to make the length of the exercise program and the daily activities of the head keep the head along the pelvis, and while bending the knee or pelvis, during the activities, the head is aligned with the backbone in a neutral and stable position. In this study, the images were prepared from an ideal spine alignment in neutral position during functional activities such as sitting, standing, and sitting to standing and sleeping. Statistical analysis was performed using SPSS 23 (SPSS Inc., Chicago, Illinois, USA). According to the result of the one sample Kolmogorov-Smirnov test (P>0.05). Based on the above conditions, a covariance analysis was used to examine the difference between the experimental and control groups.

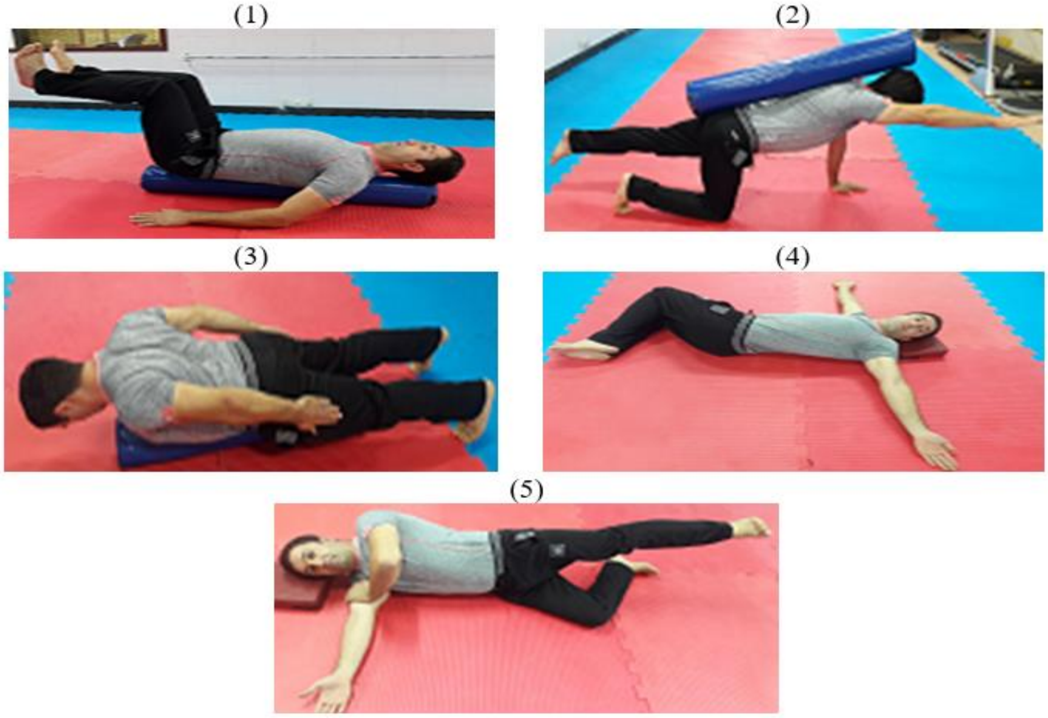

Figure 1. Spinal strengthening exercise

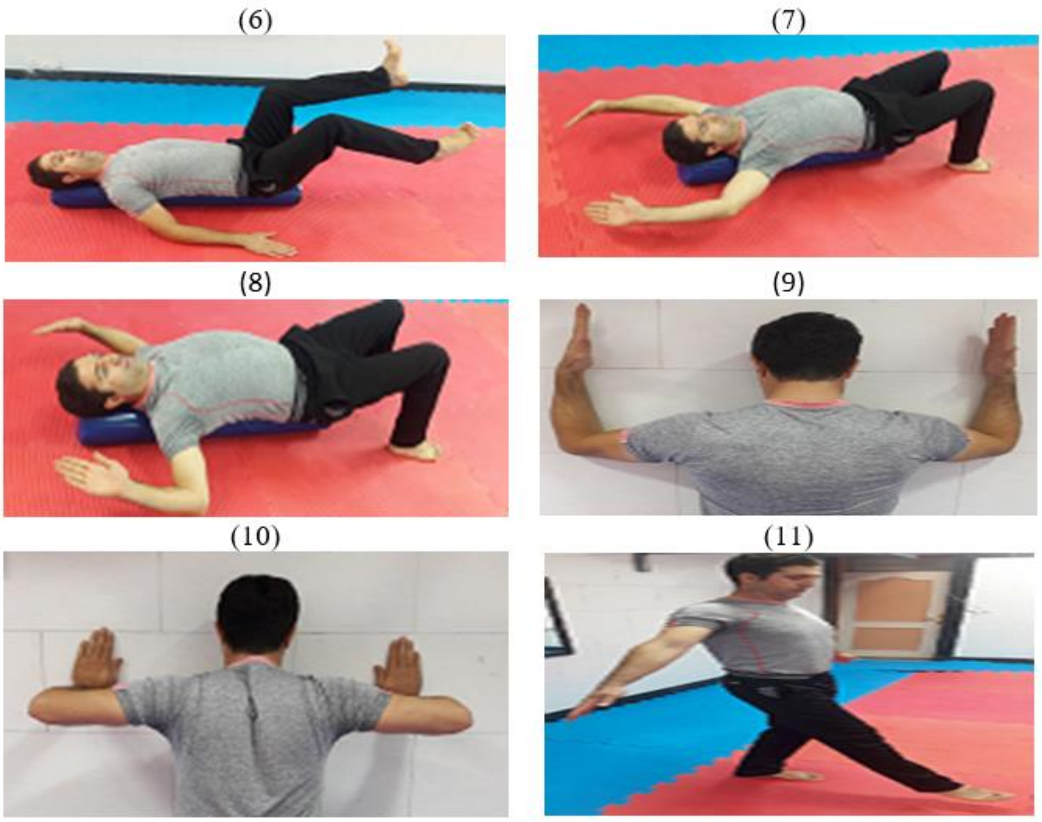

Figure 2. Spinal alignment exercise

Figure 3. **Spinal mobility exercise**

Results

Table 1 provides the baseline demographic data of all participants. The independent *t*-test showed no significant difference between the experimental t and control groups in all baseline variables.

The results of a paired-samples t-test demonstrate that the experimental group showed a significant reduction in kyphosis angle 48.00 (3.01) to 40.76 (2.30) (P<0.05). There weren't any significant changes between pretest and posttest kyphosis angle (P>0.05) (Table 2).

Posttest kyphosis angle between treatment and control groups was compared using ANCOVA after for pretest adjustments (Table 2). Results showed that kyphosis angle was significantly lower in the experimental than in the control group in measuring with flexible ruler (F=535.61 P<0.05) with strong effect sizes (partial eta-square>0.14) (Table 2).

Table 1. **Baseline characteristics of all participants**

Characteristics	Experimental group (n=47)	Control group (n=50)	P-value
Age	23.82	23.82	0.98
Height	175.38	174.14	0.43
Weight	69.76	70.92	0.50
BMI	16.48	15.46	0.31

Table 2. **Pretest, posttest, and score change between the experimental and control groups (results of paired t-test and ANCOVA for kyphosis angle comparison within and between groups)**

Variables	Experimental group (n=47)	*t* (P)	Control group (n=50)	*t* (P)	*F* (P)	*Partial eta-squared*
	Mean (SD)		Mean (SD)			
Kyphosis angle with flexible ruler		24.27 (0.001)		-1.76 (0.08)	535.61 (0.001)	0.85
Pretest	48.00 (3.01)		47.66 (2.81)			
Posttest	40.76 (2.30)		48.00 (3.04)			
Score changes	7.24 (2.04)		-0.34 (1.38)			
95% CI	6.63, 7.83		-0.73, 0.04			

*Significant at P<0.05; *t*: paired-samples *t*-test; F: ANCOVA controlling for pretest

Discussion

In a randomized controlled study, out of 97 young male participants, that 47 participants participated in the selected exercise program (spinal strengthening, spinal alignment, spinal mobility) with posture training in the active group an hour for thrice a week for the duration of 12 consecutive weeks. A decrease of 7.24 degrees was observed in the kyphosis angle of the thoracic compared to the control group, and the mean score was 48±3.01 in the pre-test which reached to 40.76±2.30 degree in the post-test. The results of the covariance analysis indicated that the corrective program had a significant effect on the reduction of kyphosis angle. The results of this study were in accordance with the findings of Katzman (2017), Jang (2015), Bansal (2014), Feng (2018), Yoo (2013) and Yelfani (2015) who reported a significant decrease in the kyphosis angle after the implementation of the exercise program **(22, 29, 30, 36, 37, 38)**.

In hyper kyphosis, the implementation of a spinal strength training protocol along with spinal alignment and spinal mobility can simultaneously reduce the kyphosis angle of affected individuals **(29)**. Trunk muscles contribute to the control of movement and stability of the spine, yet the body's deep muscles and central parts play a vital role in controlling intervertebral movements, which also brings stability to the spine in dynamic situations **(39)**. In the training program, this study attempted to strengthen the muscles of the extensor, the core muscles the central area body, and provide strengthening. In exercises, we also investigated chest muscles stretches and increasing the chest and anterior chest expansion and spinal movement. In this exercise program, we tried to perform more exercises in the close chain and in the case of weight bearing on the roller foam **(40)**. These corrective programs maintain the spine and movement and permit the body to keep the orientation of the spine automatically during static and dynamic loads **(36)**. Researchers have indicated that the following changes are created in skeletal muscle resistance training, including the increase of the total contractile protein, especially in myosin fibers, the increase of the amount and strength of tissue, the increase of the capillary density, the increase of the number of myofibril. Consequently, the longitudinal division of the blade muscle increases muscle strength and endurance. It has also been argued that flexibility exercises act as a coordinator of the agonist and antagonist muscle **(41)**. Therefore, the performed exercises in this study are likely to increase the length of the anterior chest muscles and increase the strength of the back extensor muscles and central area of the body, thereby, leading to a reduced amount of abnormality.

In the present study, the consequence efficacy of corrective exercises was observed in the decrease of the kyphosis angle (7.24 degrees). One of the most important causes of the effectiveness of this study is the use of selected strength and stretching exercises simultaneously with postural training, which led to the decrease of the kyphosis angle by coordinating agonist and antagonist muscles **(29)**. In this study, the training of postural exercises were used through audiovisual and feedback for active members of the group, so that they could use these strategies during the training period and daily activities, as they were taught to maintain a neutral spine status and alignment at all time and improve this situation during exercise. The subjects were trained to keep their head along the pelvis during their daily routine and exercise, while bending the knee or pelvis during the activities in a neutral and stable position along the spine. Katzman *et al.* **(29)** examined the efficacy of a strength exercise program for the spine with postural exercises among men and women aged 60 and older with thoracic kyphosis over 40 degrees. After 6 months of exercise and measurement with a kyphometer, results showed that kyphosis had significantly decreased (3.8 degrees). This data was consistent with the results of this research. The main reason for the slow decrease in the kyphosis angle of Katzman's research may be due to the effect of age on the rate of kyphosis. It has also been noted that some subjects had idiopathic kyphosis which affected their final results.

In a study by Feng *et al.* (2018) entitled, "The effect of a corrective functional exercise program on postural thoracic kyphosis in teenagers: a randomized controlled". The corrective functional exercise program of the mentioned study above achieved a clinically significant decrease in TKA (approximately 9 degrees), as well as changes in the sacral angle and thoracic ROM **(30)**, which is consistent with the results of this study. In the study of Seiedi *et al.* (2014), the effect of local and comprehensive correction exercises on the kyphosis angle of young individuals were studied. The researchers concluded that comprehensive exercises had a greater effect on the reduction of kyphosis curvature rate versus local exercises **(28)**. In full grown males, a program with involvement of stretching and flexion of the thoracic vertebrae and training of muscle strength released pain and reduced thoracic kyphosis by 7 degrees **(30)**. Bansal *et al.* (2014) reported in a review that studies on the effect of training intervention on kyphosis are not only of low quality but have small samples sizes and mainly produce research of moderate efficacy in improving an individual's kyphosis angle. Similarly, studies that had a randomized controlled trial, this effect was more favorable and ultimately suggested that randomized controlled studies were carried out with a high sample size (22). The researchers of this study, by considering the results of domestic and international performed researches and review studies on the effect of intervention on hyper kyphosis, which mainly recommended the implementation of simultaneous strength and stretching exercises along with postural exercises with a randomized controlled trials with a high sample size, attempted to correct functional kyphosis in young people, as the performed exercises in this study were similar to Katzman's exercises, derived from a corrective exercises series to correct hyper kyphosis abnormalities, which its favorable results has been published on reducing the angle of hyper kyphosis on the elderly (29).

Hence, the investigator, while implementing the exercise program (spinal strengthening, spinal alignment and exercises for increased spinal mobility), simultaneously, also used postural exercises to increase the exercise's usefulness for the participating group in order to control the effective reduction and long-term effects of exercises on hyper kyphosis anomalies.

In this study, 97 subjects with hyper-kyphosis abnormalities were selected in relation to a randomized controlled trial. According to the findings of this study regard the optimal effect of corrective exercises in this study, along with postural exercises in improving hyper-kyphosis in young people, it is suggested to researchers and professionals to use these exercises in combination with posture correction exercises.

Conclusion

The results of this study showed that 12 weeks of selected exercises (spinal strengthening, spinal alignment and exercises for increased spinal mobility) along with postural exercises can reduce the angle of kyphosis in young people with hyper-kyphosis. This appears to be due to the simultaneous attention on postural exercises, in addition to strength, mobility, and spinal alignment exercises. Therefore, as a general conclusion, the results of this study can highlight the need for spinal strength, mobility, and alignment exercises along with postural exercises. It is suggested that researchers consider this selected corrective program as a new method and replacement of former corrective exercises.

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Conflict of Interest

Authors declared no conflict of interests.

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