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Comparing the Effect of Functional Corrective Exercises Versus Core Stability Exercises and a Combined Program on Forward Head Posture and Kyphosis in Female Adolescence

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ABSTRACT

Background: Forward head posture (FHP) and kyphosis are the most common postural deviations which various factors are involved in the occurrence of these abnormalities. This study aimed to compare the effect of functional corrective exercises (FCE) and core stability exercises (CSE) on forward head posture and kyphosis in adolescent girls.
Methods: The present study is quasi-experiment research and included a pre- and post-test design. 52 students aged 14-16 years old with forward head posture >46 degrees and kyphosis >40 degrees were randomly assigned into four groups, each one consisting of 13 students. Research tools for kyphosis as well as forward head posture assessment included flexible ruler and goniometer, respectively. The experimental groups participated in training programs for 6 weeks, three times per week and for 60-minutes per session, while the control group continued their daily routine activities. The data analysis was carried out using covariance (ANCOVA) analysis via SPSS, version 21.
Results: The outcomes showed that there were significant differences among groups, including core stability exercises (CSE) and combined exercises (FCE+CSE) (P=0.020), core stability exercises (CSE) and Control (P=0.008), functional corrective exercises (FCE) and Control (P=0.001), combined exercises (FCE+CSE) and Control (p= 0.001) with respect to kyphosis. For the Forward head posture (FHP) variable, there were significant differences between pre- and post-tests of core stability exercises (CSE) and Control (P=0.001), functional corrective exercises (FCE)and combined exercises (FCE+CSE) (P=0.019), functional corrective exercises (FCE) and Control (P=0.001) as well as combined exercises (FCE+CSE) and Control (P=0.001) groups. There was no significant difference between pre- and post-test measures of control group.
Conclusion: According to this study's results, although all types of training programs had a significant effect on postural correction, but a combined exercises (FCE+CSE) significantly improved forward head posture and kyphosis combined to each training program. Therefore, it is recommended that healthcare professionals and corrective exercise specialists to implement a combined program to have a better result in terms of kyphosis and forward head posture correction.

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Introduction

According to epidemiological studies, a high prevalence of spinal postural deviations was reported in

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children and adolescents resulting in a high prevalence of upper quadrant musculoskeletal pain among them [1]. Forward head posture (FHP) and kyphosis are two of the most common postural deviations in people of all ages, accounting for 13.2% and 14% in adolescent girls of Iranian and Western populations, respectively [2-4]. This condition is generally seen concurrently, although the etiology of abnormality is not clearly stated. Some studies suggested that hyper kyphosis causes FHP, but other ones proposed that FHP causes hyper kyphosis [5]. Nevertheless, it is clearly confirmed that FHP is associated with an increased kyphotic thoracic spine or thoracic hyper kyphosis [5]. FHP and kyphosis may result in extensive changes including muscle imbalances and fatigue, increased cervical lordosis, scapular winging and decreased stability in glenohumeral joint, compromised airway function, esthetic issues, chronic facial tension, herniated cervical intervertebral discs, etc. [4, 6].

FHP prevalence differs between two gender groups, and hence the prevalence ratio of this postural abnormality was estimated, 60.3% and 40.6%, among girls and boys, respectively [5]. There is a relationship between FHP in standing posture and lack of abdominal muscle control, which in turn aggravates thoracic kyphosis [5], it seems reasonable that implementing a training program that could aid spinal realignment may improve FHP. Furthermore, Sun-Myung et al., recommended that training regimens focusing on core muscles are appropriate exercises for the treatment of FHP in sedentary individuals [7]. The authors also indicated that functional programs resulting in whole-body muscle retraining outweigh the programs focusing on specific (cervical or thoracic) regions [7].

Other researchers indicated that combined stretching and strengthening exercises improved FHP and round shoulder [8, 9]. Due to the contradictory results from different studies, it still is unclear that which types of exercise programs can be more beneficial. Furthermore, recent investigators clearly stated that future studies should include corrective exercise programs, which might be more useful [7].

Moreover, though, clinicians commonly use corrective exercise protocols as a therapeutic intervention to target this misaligned posture [10, 11], but few studies have examined the effect of targeted corrective exercise programs simultaneously on FHP and kyphosis. Nonetheless, corrective exercise programs probably decrease the percentage of muscle activity required for good posture maintenance and would minimize muscles fatigue in those muscles. Therefore, this study aimed to assess and compare the effect of functional corrective exercises (FCE), core stability exercises (CSE) and a combined exercises (FCE+CSE) on FHP and kyphosis in female adolescence.

Methods

The present study was quasi-experiment research and included a pre- and post-test design. The statistical population consisted of 52 high school girls aged 14-16 years with FHP and kyphosis who had reached puberty. To determine sample size in interventional studies with the effect size of (P≥0.8), the level of (α=0.05) and (β=0.20) considered acceptable. Thus, using G*Power and due to the analysis of covariance (ANCOVA) utilized in this study as well as groups, a sufficient sample size (40 individuals) obtained. Both students and parents filled in the consent form before commencing the study. Besides, the procedures were approved by the ethics committee of Urmia University of Medical Sciences (IR.URMIA.1398.002). Angles greater than more than 46 degrees were considered as forward head and angles greater than 40 degrees were considered kyphosis as inclusion criteria [12, 13].The exclusion criteria were a history of fractures, surgery, or joint diseases, especially in the spine, shoulder girdle, and pelvis; skeletal malalignment in the ankle and knee; pain in upper and lower extremities; vestibular system impairment; regular exercise training participation, withdrawal from a study and being absent for more than two sessions. Besides, participants who self-reported that they were not matured could not enter the study. Participants were selected purposefully and divided randomly into four groups, including FCE (13 people), CSE (13 people), FCE+CSE (13 people), and control group (13 people).

Thoracic kyphosis was measured in each subject using the flexible ruler (Staedtler Mars, Inc, Nurnberg, Germany), a malleable metal band covered with plastic and approximately 60 cm in length [14]. The ruler can be bent in only one plane and retains the shape to which it is bent. The subject was instructed to stand up straight and as tall as possible, and the flexible ruler was aligned to the anterior-posterior curves of the spine from T1 to T12. The ruler was then placed flat on paper, and its outline was traced. A straight line was then drawn from the ruler position of T1 to T12 that corresponded to the length of thoracic kyphosis and was measured in cm. The height of the thoracic kyphosis (h) in cm was determined by drawing a perpendicular line from the highest point in the thoracic curve to the point at which it intersected the straight line drawn from T1 to T12. The index of kyphosis was calculated by applying the formula: Kyphosis Angle=4×[arc tan (2H/L] [12, 14]. Measurement was conducted three times. The Intraclass Correlation Coefficient (ICC) was 0.92 and 0.92 for thoracic curvature (Figure 1) [15].

To assess FHP, participants were asked to stand while the body is located in upright and normal posture. Then the seventh cervical vertebrae were found and marked by finding its bony landmark by asking the person to flex and extend her head 3 times and then find the seventh spinous process of the vertebra. The participant was then asked to stand while looking ahead, the experimenter then placed

Figure 1: Kyphosis measurement

on the right side of the individual, and goniometer was placed in such a way that the central line of transparent movable arm passes through the Tragus of the right ear and seventh cervical vertebra [12, 13]. Then, the angle of the arrow on the conveyor was recorded. The angle of FHP was calculated based on the angle between the line connecting Tragus of the ear and seven cervical vertebrae to the horizontal. If the angle was greater than 46 degrees, then referred to as FHP (Figure 2) [16, 17].

Figure 2: Forward head posture (FHP) measurement

First of all, the participants were given a list and description (with illustrations) of each exercise and were required to show their ability to execute each exercise correctly. The training programs consisted of five exercises, including stretching, strengthening, and core exercises as illustrated in Tables 1 and 2. The training protocols were to be repeated three times per week for 6 weeks, under the direct supervision of a corrective exercise specialist. The exercise program was done according to previous scientific texts and studies [18-20]. We commenced our training program with one set

Table 1: Functional corrective exercises (FCE)

Muscle/segment	Training per week	Set	Repeated	Duration (sec)
Upper trapezius stretch	Three sessions	1-3	6-12	5-30
	In a seated position, the subject places her behind her head and lightly applies pressure downward. This exercise stretches the upper trapezius muscle. (Figure 3)			
Foam roll Pec Stretch	Training per week	Set	Repeated	Duration (sec)
	Three sessions	1-3	6-12	5-30
	In a prone position with bent knees, the subject lays on the back on a foam roller so that the foam roller is up against the spine while placing the shoulders and elbows at 90 degrees. Letting arms relax down and then performs external rotation. (Figure 3)			
Prone Pec Stretch	Training per week	Set	Repeated	Duration (sec)
	Three sessions	1-3	6-12	5-30
	In a prone position, while holding the arms near the ears, the subject places the arms on the foam roller. After the first weeks, a foam roller will be placed closer to the body. (Figure 3)			
Seated Row	Training per week	Set	Repeated	Duration (sec)
	Three sessions	1-3	6-12	5-30
	The subject should stand tall with each end of resistance band (in blue, Ghamat pooyan company) in her hands, knees slightly bent, abdominal muscles tight. While, maintaining tight trunk muscles, pull arms back, and squeeze shoulder blades together, she should focus on squeezing the shoulder blades without shrugging the shoulders up towards the ears. Return to starting position without leaning backward. (Figure 3)			
Middle Trapezius Strengthening	Training per week	Set	Repeated	Duration (sec)
	Three sessions	1-3	6-12	5-30
	In a prone position on the bench while subjects keeping chin tuck position and raising their arms to the 120-degree and parallel to the bench level, she keeps this position to strengthen the middle and lower trapezius as well as Rhomboid and deep flexor muscles of the neck. (Figure 3)			

Table 2: Core stability exercises (CSE)

Muscle/segment	Training per week	Set	Repeated	Rest (sec)
Quadruped Hip Extension	Three sessions	1-3	10-15	5-30
	In a quadruped position, the subject should maintain the neutral alignment of the neck, trunk, and spine. Legs alternatively extend while performing chin tuck simultaneously. These exercises *Strengthen the* back, glutes, and erector spinae muscles. (Figure 4)			
Bird Dog	Training per week	Set	Repeated	Rest (sec)
	Three sessions	1-3	10-15	5-30
	In this exercise, subject, in a quadruped position, extends the opposite arm and leg alternatively. Back muscles, glutes, erector spinae, middle trapezius, front deltoids, and neck flexors are targeted muscles for strengthening. (Figure 4)			
Side Bridge	Training per week	Set	Repeated	Rest (sec)
	Three sessions	1-3	10-15	5-30
	In this exercise, the subject lies on one side with the forearm at 90-degree bent knees while keeping the alignment of head, neck, and trunk. Obliques and rectus abdominis are targeted muscles for strengthening. (Figure 4)			
Prone Plank	Training per week	Set	Repeated	Rest (sec)
	Three sessions	1-3	10-15	5-30
	Subject place hands with a straight arm and rest the knees on the floor. While keeping the body weight on hands and knees, the subject maintains a lumbar curve in a neutral position. Rectus abdominis and neck flexors are targeted muscles for strengthening. (Figure 4)			
Bridging	Training per week	Set	Repeated	Rest (sec)
	Three sessions	1-3	10-15	5-30
	In this exercise, the subject lies on the back and bends the knees while keeping the bridge position. Abdominal, trunk extensors, and hamstrings are targeted muscles for strengthening. (Figure 4)			

Figure 3: Functional corrective exercises (FCE)

of each exercise for the first two weeks and then added one set every two weeks reaching three sets at the fifth and sixth week.

It should be noted that our combined program consisted of FCE and CSE.

Descriptive statistics were used to describe the basic features of the data in this study. To apply statistical tests, the normal distribution of variables being studied determined by the Kolmogorov Smirnov test, and due to the normalcy of variables, analysis of covariance (ANCOVA) used to compare means of variables. Data were analyzed using SPSS version 22. The significance level was chosen at $P \leq 0.05$.

Figure 4: Core stability exercises (CSE)

Results

The results of descriptive statistics of individual's demographic characteristics presented in Table 3.

The results of descriptive statistics of the research variables are presented in Table 4.

Data normalcy, homogeneity of variance, and homogeneity of regression slopes were considered three presumptions to study the research hypothesis and the results obtained below. According to the results of analysis of covariance (ANCOVA) presented in Table 5, FCE, CSE, and FCE+CSE all had a significant effect on kyphosis ($F_{(47,3)}$=16.091, P=0.001)). Effect size (η2=0.507) obtained for kyphosis indicates that the test's statistical power is high. The results of ANCOVA also showed that FCE, CSE and FCE+CSE had a significant effect on FHP ($F_{(47,3)}$=36.174, P=0.001)) and effect size (η2=0.698) obtained for FHP indicating high statistical power.

To determine which means are significantly different among the groups and which type of training had a

Table 3: Demographic characteristics of participants

Variable / Group	FCE	CSE	FCE+CSE	Control
	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Weight (kg)	57.37±2.25	58.34±2.42	57.00±2.18	54.65±2.64
Age (yrs.)	15.13±0.50	15.28±0.46	14.92±0.42	15.01±0.45
Height (cm)	159.30±3.14	160.69±2.62	159.92±2.06	158.38±2.95
BMI (kg/m^2)	22.45±0.65	22.44±0.41	22.28±0.76	21.79±1.04

FCE: Functional corrective exercises; CSE: Core stability exercises; FCE+CSE: Combined exercises; BMI: Body mass index

Table 4: The results of descriptive statistics of research variables

Variable	Group	FCE	CSE	FCE+CSE	Control
	Time	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Kyphosis	Pretest	44.96±1.68	44.61±1.62	46.11±2.18	46.09±1.42
	Posttest	41.80±1.56	41.96±1.50	41.61±1.58	44.25±1.08
FHP	Pretest	47.50±1.11	47.26±0.69	47.84±0.94	47.76±1.11
	Posttest	43.69±1.56	43.80±1.26	42.23±1.31	47.34±1.17

FCE: Functional corrective exercises; CSE: Core stability exercises; FCE+CSE: Combined exercises; FHP: Forward head posture

Table 5: ANCOVA results for comparison of different types of training on kyphosis and Forward head posture (FHP)

Dependent variable: post-test					
Variable	**DF**	**Mean squared**	**F**	**Sig.**	**Partial Eta Squared**
Kyphosis	3	15.757	16.091	0.001*	0.507
FHP	3	60.732	36.174	0.001*	0.698

Significance level: P≤0.05*; FCE: Functional corrective exercises; CSE: Core stability exercises; FCE+CSEFCSE: Combined exercises; FHP: Forward head posture

Table 6: Bonferroni post-hoc test for post-test pairwise comparisons of kyphosis and Forward head posture (FHP) with excluded pre-test effect

	St. Error		Mean Difference		Sig.	
	Kyphosis	**FHP**	**Kyphosis**	**FHP**	**Kyphosis**	**FHP**
CSE- FCE	0.365	0.206	0.389	0.510	1.000	1.000
CSE- FCE+CSE	1.261	1.809	0.407	0.520	0.020*	0.007
CSE- Control	-1.389	3.342	0.406	0.517	0.008*	0.001*
FCE- FCE+CSE	0.896	1.597	0.399	0.512	0.177	0.019*
FCE- Control	-1.754	-3.548	0.399	0.511	0.001*	0.001*
FCE+CSE- Control	-2.651	-5.146	0.388	0.508	0.001*	0.001*

Significance level: P≤0.05*; FCE: Functional corrective exercises; CSE: Core stability exercises; FCE+CSEFCSE: Combined exercises; FHP: Forward head posture

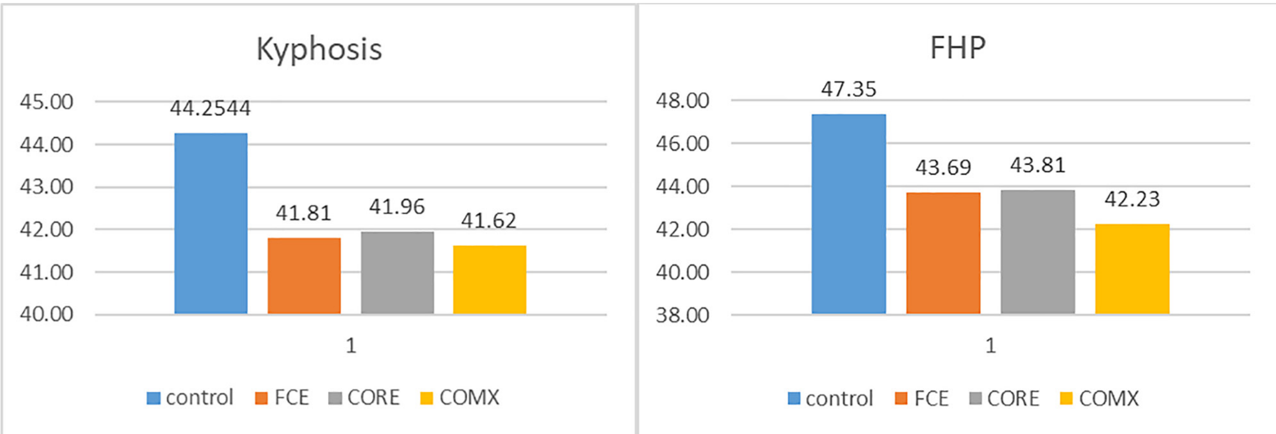

Figure 5: Charts for comparison of different types of training on kyphosis and Forward head posture (FHP)

better effect in reducing FHP as well as kyphosis angle, Bonferroni post-hoc test was used which presented in Table 6. According to the results gained from Bonferroni post-hoc test, significant differences exist in kyphosis angle between CSE and FCE+CSE (P=0.020), CSE and control (P=0.008), FCE and control (P=0.001), and FCE+CSE and control (P=0.001) groups. There is also a significant difference in term of FHP angle among all training groups such as CSE (P=0.001), FCE (P=0.001), and FCE+CSE (P=0.001) with the control group as well as between FCE and FCE+CSE (P=0.019) groups (Figure 5).

Discussion

This study aimed to compare the effect of FCE, CSE and a combined exercises (FCE+CSE) on FHP and kyphosis in female adolescence. Some studies focused on isolated stretching–strengthening exercises to correct these postural deformities, but these postural deviations are linked and associated with daily life activities [9], thus implementing a program which is functional might bring more advantages. The present study showed improvements in FHP and kyphosis after performing all three types of exercises such as FCE, CSE with regard to FHP and with regard to kyphosis as well as the combined exercises. More specifically, the outcomes of this study showed that FCE resulted in deceased FHP and kyphosis angles which is consistent with previous researches [21-23].

Ball et al. indicated that back extensor strengthening exercises are useful to delay the progression of kyphosis in women older adults [22]. Other researchers emphasized this fact that strengthening the thoracic extensor and scapular retractor muscles as well as stretching pectoralis muscles through flexibility exercises can improve hyper kyphosis [1, 22]. Indeed, we have also included pectoralis muscle stretching exercises in our program design. Besides, it was shown that prone arm abduction/ shoulder flexion can increase muscle activity of the middle and lower parts of trapezius muscle [24, 25], which are weakened muscles in FHP and kyphosis. To justify our results, there are similar exercises concentrating on trapezius muscles which were considered by authors when designing the FCE program and cannot be neglected as a possible explanation of postural improvements in terms of FHP and kyphosis angles obtained in this study. Sayyadi et al. observed that participants lost, rapidly than expected, the improvements in kyphosis angle in a follow up period. Furthermore, since functional exercises, due to the specific adaptation of imposed demands principle, are more practical to stimulate muscles and movements recruited in daily life activities, these types of exercises should be added to corrective exercise programs [26]. Miguel Ruivo et al., Seidi et al., Lynch et al., and Katzman et al. employed similar exercises that enhanced the thoracic extension and reduced hyper kyphosis [1, 21, 27, 28].

In one study, researchers stated a relationship between upright human posture regulation and reflexive mechanisms occurred within the head and neck region [29]. In another study, researchers reported that abnormal spinal curvatures increase the likelihood of whiplash injury and may have long-term clinical and biomechanical implications [30]. The importance of posture to achieve a first-class lever mechanical system was well documented, and postural stability is its cornerstone. We decided to implement core exercises for postural correction. Our study results show reduced FHP and kyphosis posture in the sample following the CSE execution compared to the control group, which emphasizes this notion by itself. Moreover, although it was documented that core muscles are vital for the maintenance of spine alignments [31], but to the best of our knowledge, this is the first study aimed to assess the effectiveness of core stability exercises on FHP and kyphosis, and this fact makes it very difficult for any comparison with other studies. In one study conducted by Jeoung-Ah Ahn et al., core strengthening exercises performed on a Swiss ball effectively reduced pain and increased range of motion [31]. Nonetheless, implementation of core exercises on balls cannot be compared with our results since the extend of movement becomes limited by the diameter of the ball and also differences in terms of movement patterns while performing on a dynamic (Swiss ball) versus static (mat) surfaces [31]. They also evaluated pain and neck range of motion which are totally different outcomes compared to ours.

According to previously published studies, several modalities have been reported as effective to correct postural deviations, FHP, and kyphosis, including manual therapy, postural re-education, using taping and orthoses, and exercise therapy [9, 30, 32, 33]. The purpose of designing and applying all of these modalities, especially corrective exercises, is to enhance the range of motion, improve flexibility, increase the strength of the weakened muscles, and generally, eliminate muscle imbalance. For this reason, researchers have always attempted to combine corrective exercise programs for maximal achievements [18]. We also combined FCE with CSE.

combined exercises (FCE+CSE) resulted in larger improvements in kyphosis than the CSE group. There was no difference in FHP values. In addition, FCE+CSE significantly improved FHP compared to the FCE group.

To the authors' knowledge, no study has investigated the combination of corrective exercises with CSE on FHP and kyphosis; hence the results of this study cannot be directly compared with the results of other studies. Mousavi et al. compared the effect of corrective exercises program with the myofascial release and concluded the combined program was more effective than the corrective exercises alone in correcting the forward shoulder deformity [30]. Other studies have also indicated that combining spinal strength exercises with stretching exercises can reduce the degree of forward shoulder posture angle in the affected population [1, 18], which is consistent with our research. Research limitations included: eating habits, personal habits, amount of daily activities, time, and volume of training in different training groups.

Conclusion

According to the outcomes of present study, people with FHP and kyphosis experienced improvements in postural deviations after completing training programs. Overall, a combined exercises (FCE+CSE) consisting of FCE and CSE resulted in bigger improvements. Thus, it seems that all types of exercises used in this study can be of value to implement for people with FHP and kyphosis deviations.

Conflict of Interest: None declared.

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