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Comparison of Respiratory Pattern and Core Muscle Function in Students with and Without Postural Thoracic Hyper kyphosis

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Authors

Zahra Khamis-Abadi[1],
Hashem Piri1[*1]
Rahman Sheikhhoseini[1]
Mohammad Mashhadi[1]

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[1] Department of Corrective Exercise and Sport Injury, Faculty of Physical Education and Sport Sciences, Allameh Tabataba'i University, Tehran, Iran

** Correspondence*
Department of corrective exercise and Sport injury, Faculty of physical education and sport sciences, Allameh Tabataba'i University, Tehran, Iran.
ORCID: 0000-0002-9885-3591
P.O.BOX: 1485643449
Tel : 0098 2148394134
Fax: 0098 2148390000
E-mail: Rahman.pt2@gmail.com

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ABSTRACT

Aims: Considering the importance of physical health among school-aged students, evaluating the effects of common spinal postural deviations on respiratory function and core muscle performance is essential. This study aimed to compare the respiratory pattern and core muscle function in students with and without postural thoracic hyperkyphosis.

Method and Materials: In this cross-sectional comparative study, 88 male and female middle and high school students in Karaj, Iran, aged 13–18 years in 2024, with and without postural thoracic hyper kyphosis, were recruited voluntarily. The thoracic kyphosis angle was assessed using a flexible ruler. Core muscle endurance was evaluated using McGill's trunk endurance tests, including trunk flexor, trunk extensor, and lateral trunk endurance tests. Respiratory pattern was assessed by measuring chest and abdominal circumference changes. Data were analyzed using an independent samples t-test, and the significance level was set at $P<0.05$.

Findings: In this study no significant differences were observed between groups in flexor endurance ($P = 0.119$, $d = -0.34$, 95% CI: -0.76 to 0.08), extensor endurance ($P = 0.723$, $d = -0.07$, 95% CI: -0.49 to 0.35), or lateral muscle endurance ($P = 0.197$, $d = 0.29$, 95% CI: -0.13 to 0.71). However, statistically significant differences were found in abdominal breathing excursion ($P = 0.006$, $d = 0.59$, 95% CI: 0.17 to 1.01) and thoracic breathing excursion ($P = 0.001$, $d = 0.74$, 95% CI: 0.30 to 1.18), with the healthy group demonstrating significantly greater thoracic and abdominal excursion.

Conclusion: Thoracic postural hyper kyphosis in students may be associated with alterations in respiratory pattern. Therefore, respiratory function assessment along with postural evaluation may be considered in school health screening programs and corrective exercise interventions.

Keywords: Respiratory Pattern, Core Muscle Function, Hyper kyphosis, Thoracic

Introduction

Posture is defined as the relative arrangement of body parts. Under musculoskeletal balance, muscle efficiency is maximized, and minimal stress is imposed on the body [(1)]. Maintaining proper posture depends on the coordinated interaction of the musculoskeletal system and plays an important role in efficient movement, physical performance, and reducing mechanical stress on body structures. Prolonged improper postural habits may contribute to the development of spinal deformities and functional limitations, particularly during adolescence when rapid growth and lifestyle changes occur [(2)]. The spine and its curvatures are crucial for optimal posture. Thoracic kyphosis refers to the sagittal plane curvature from the first to the twelfth thoracic vertebra [(3)].

Hyper kyphosis, or excessive posterior curvature of the thoracic spine, is a common abnormality characterized by increased thoracic curvature, scapular abduction, and rounded shoulders [(4)]. Studies have shown that increased thoracic kyphosis is associated with reduced physical performance, impaired pulmonary function, forward head posture, decreased neck mobility, and increased neck pain [(5)].In hyper kyphosis, anterior thoracic muscles (pectoralis major and minor) tend to be tight while posterior muscles (spinal extensors) tend to be weak, leading to muscle imbalance [(6)]. Acquired hyper kyphosis may result from poor posture, imbalance between anterior and posterior trunk muscles, increased anterior pelvic tilt, excessive trunk flexion exercises, physical inactivity, ectomorphic traits, and aging [7].

Normal kyphosis angles range from 20° to 40° in young individuals [8]. Angles exceeding 70° are considered severe. Hyperkyphosis is also associated with impaired physical function, reduced pulmonary function, and increased risk of vertebral fractures [9]. Research indicates that respiratory indices are significantly lower in the kyphosis group than in those without the abnormality [10]. The respiratory system supplies oxygen for metabolism and eliminates carbon dioxide [11], working with the circulatory system to deliver oxygen to tissues [12].

Core stability offers extensive benefits, including improved sports performance, injury prevention, and reduction of musculoskeletal disorders [13]. The core prevents spinal instability and restores balance after perturbations [14]. Proper core function preserves normal length-tension relationships, leading to optimal joint kinematics and providing maximal stability [15]. Specifically, spinal kyphosis limits chest wall movement during inspiration, leading to respiratory insufficiency [16]. Increased thoracic kyphosis may affect thoracic mobility, chest wall mechanics, respiratory muscle function, and ventilation efficiency. Previous studies have reported associations between thoracic kyphosis and changes in respiratory function, suggesting that spinal alignment may influence breathing patterns through alterations in thoracic structure and muscle coordination [16,17]. Furthermore, kyphosis increases the load on chest and neck muscles, accelerating respiratory muscle failure [18]. Daneshmandi et al (2004) reported a significant relationship between kyphosis angle and respiratory volume in students [19]. In addition, respiration and core stability are functionally interconnected through the activity of the diaphragm and deep trunk muscles [20]. Sato et al (2021) demonstrated lower diaphragm mobility in patients with thoracic hyper kyphosis and a negative correlation between kyphosis angle and diaphragm mobility [21].

Although previous studies have examined the relationship between spinal posture and respiratory function, limited information is available regarding the simultaneous evaluation of respiratory pattern and core muscle endurance in school-aged students with thoracic postural hyper kyphosis. Therefore, this study aimed to compare respiratory pattern and core muscle endurance between students with and without thoracic postural hyper kyphosis.

Method and Materials

This cross-sectional comparative study aimed to compare respiratory pattern and core muscle function in students with postural thoracic hyper kyphosis and healthy students. The study population included middle and high school students aged 13–18 years. Participants were recruited voluntarily. They were classified based on their thoracic kyphosis angle measured at a single time point. The exposure (hyperkyphosis) and outcomes (respiratory pattern and core muscle function) were assessed concurrently, which is consistent with the cross-sectional design. Schools were selected using a convenience sampling approach from among middle and high schools in Karaj, Iran. After coordination with the Karaj Education Administration, three volunteer schools were identified for this study. After visiting these schools, the researcher introduced the project and obtained informed consent from the students' legal parents before conducting sampling.

The sample size was determined a priori using G*Power software (version 3.1.9.7). Based on previous studies examining respiratory differences between hyper kyphosis and healthy groups (10), an effect size of Cohen's *d* = 0.60 was assumed. With an alpha level of 0.05, statistical power of 0.80, and a two-tailed independent samples t-test, the required sample size was calculated as 45 participants per group. To account for potential attrition, we aimed to recruit 50 participants per group. A total of 100 students were screened, and 88 participants met the eligibility criteria and completed the study (44 participants in each group). Matching was performed manually by the research team before data collection. After screening, 88 participants were successfully matched, while 12 participants were excluded due to inability to find an appropriate match. After matching and applying exclusion criteria, 44 participants per group were available for analysis (achieved power = 0.78). Inclusion criteria were: age 13–18 years, thoracic kyphosis angle >40 (hyper kyphosis group) or normal angle, and no other musculoskeletal abnormalities. Exclusion criteria included a history of surgery or injury to the cervical or lumbar spine or congenital abnormalities. Written informed consent was obtained. Participants refrained from strenuous activity for 48 hours before testing.

The thoracic kyphosis angle was assessed using a flexible ruler method. The flexible ruler is a practical and non-invasive tool commonly used for evaluating spinal curvature and postural deviations. This tool is a lead device with a plastic coating that bends in only one plane and maintains its shape. The subject was asked to stand upright and look at a point in front of him. After waiting about a minute to determine the subject's natural position, the flexible ruler was placed along the marked points on the spine, and gentle pressure was applied to it to mold the curvature of the spine. Then, the ruler was carefully transferred to white paper so as not to distort its shape, and the curves were marked with a pencil. The length of the chest (A) was determined by drawing a straight line from the C7 to T12 spinous processes and measuring in centimeters. The height of the chest (H) was also determined based on a straight line from the apex of the chest curve to the horizontal line. Previous studies demonstrated excellent intra rater (ICC = 0.94) and good interrater (ICC = 0.86) reliability for this method [22]. The angle was then obtained using the following formula:

Kyphosis angle = 4 Arc tang (2H/L)

Core muscle function was assessed using the McGill endurance tests (23). Before the tests began, the subjects were told to resist falling to their limits. Each movement was performed to its limits and repeated twice. A 5-minute break was allowed between each repetition so that the subject could rest. If, for any reason, the subject could not resist the examiner's movements or used other limbs to help, they were given a break, and the movement was repeated.

Trunk Flexion Test (TFT) was used to assess anterior core muscle endurance. In this test, the participant sat on the floor with the trunk supported at a 60-degree angle, while the head and neck were in a neutral position. The knees and hips were flexed at 90 degrees, and the hands were placed on the chest. The trunk support was then moved approximately 10 cm backward, while the participant maintained a 60-degree position parallel to the support. The subject was asked to maintain the isometric position as long as possible, and the time was stopped, and the individual’s score was recorded when any part of the back made contact with the plate.

The Trunk Extensor Test (TET) was used to assess the spinal erectors and the multifidus. In preparation for the test, the lower half of the body was attached to a bench using two or three straps. The straps were positioned and fastened loosely to the patient. The patient was asked to place their arms and body weight on the seat in front of the bench. To begin the test, the participant was instructed to raise their upper body so that it was parallel to the floor and to fold their arms across their chest and hold this position for as long as possible. The time the participant could maintain the test position was measured using a stopwatch. The test was terminated if the participant's upper body fell more than 5 to 10 degrees below the horizon. The participant had to maintain this position for a maximum of 240 seconds. The participant was stopped from continuing the test if pain or other symptoms were elicited. During the test, patients were given verbal feedback and, if their upper body fell below the horizontal position, they were allowed to return to a neutral position to continue the test.

Lateral Muscle Complex Assessment Test: This test was used to assess the transverse and oblique abdominal muscles, as well as the quadratus lumborum. Participants were asked to lie on their side to assess the strength of the lateral muscles in the trunk. The legs were extended, and the top leg was placed in front of the bottom leg for support. The subject had to raise their upper body and pelvis directly off the surface, supporting their body weight with the forearms and lower legs. The participant maintained this position for as long as possible, and the examiner recorded the time before the pelvis dropped. The test was repeated for the opposite side, with a 5-minute rest period between tests.

Method of measuring respiratory pattern with a meter: First, the person was asked to sit on a chair and exhale and hold his breath. Then, using a meter, the chest circumference at the level of the xiphoid process and the diameter of the abdominal area at the level of the umbilicus were measured in centimeters. This process was repeated three times, and the average was recorded as the initial data. After that, the person was asked to take three normal breaths, and in each of the three breaths, the breath had to be stopped and held at the beginning of the exhalation phase, and the chest circumference was measured at the level of the xiphoid process. The average of the three times was recorded as the breathing time data. Then, the average data for the air-discharge state were subtracted from the average value for the breathing state, yielding the amount of chest displacement during breathing in centimeters. The same method was used to measure the amount of abdominal displacement at the level of the umbilicus.

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Several potential confounding variables were considered in this study. Matching was performed to control for age, sex, BMI, and physical activity level (as described above). However, other factors such as habitual posture during daily activities (e.g., sitting time, backpack use), nutritional status, and socioeconomic factors were not directly measured or controlled.

Data were described using means and standard deviations. Normality was assessed using the Kolmogorov–Smirnov test. Independent t-tests were used to compare variables between the two groups. SPSS version 26 was used, with significance set at $P<0.05$. The study complied with the Declaration of Helsinki.

Findings

Demographic characteristics are presented in Table 1. Comparison of core muscle function showed no significant differences between groups in trunk flexor endurance (P=0.119), trunk extensor endurance (P=0.723), or lateral trunk endurance (P=0.197) (Table 2). However, significant differences were found in abdominal breathing pattern (P=0.006) and thoracic breathing pattern (P=0.001), with the healthy group showing better respiratory patterns.

Table 1) Demographic characteristics of participants

Group	Age (years) Mean (SD)	Body weight (kg) Mean (SD)	Height (cm) Mean (SD)
Hyper kyphosis (n=44)	15.29 (2.21)	54.79 (4.81)	170.33 (6.76)
Healthy (n=44)	14.79 (2.16)	67.18 (7.74)	170.72 (7.56)

Table 2) Comparison of core muscle function and respiratory pattern between groups

Variable	Hyper kyphosis group (n=44) Mean ± SD	Healthy group (n=44) Mean ± SD	t	P-value
Trunk flexor (sec)	53.95±18.39	60.95±23.06	1.57	0.119
Trunk extensor (sec)	21.59±13.07	22.56±12.71	0.356	0.723
Lateral trunk (sec)	42.36±17.48	37.38±16.74	-1.30	0.197
Abdominal breathing (cm)	1.88±0.50	2.27±0.78	2.84	0.006
Thoracic breathing (cm)	3.50±1.37	2.68±0.72	3.49	0.001

Discussion

The present study aimed to compare respiratory pattern and core muscle endurance between students with and without thoracic postural hyper kyphosis. The moderate to large effect sizes observed for respiratory patterns (abdominal breathing: d = 0.59; thoracic breathing: d = 0.74) suggest clinically meaningful differences between groups. Specifically, the 0.39 cm reduction in abdominal excursion and the 0.82 cm increase in thoracic excursion in the hyperkyphosis group reflect a shift from diaphragmatic to chest-dominant breathing. This altered pattern, if sustained over time, may contribute to reduced respiratory efficiency, increased accessory muscle use, and potentially greater respiratory effort during physical activities. The effect sizes for core endurance, however, were small (d ranging from -0.34 to 0.29) and their confidence intervals crossed zero, indicating that core muscle function may not be substantially impaired in this population, possibly due to early-stage hyperkyphosis or compensatory neuromuscular adaptations.

The main findings showed that students with thoracic postural hyper kyphosis had poorer respiratory patterns than healthy students, whereas no significant differences were observed in core muscle endurance variables. The findings showed that healthy students had a more favorable respiratory pattern than those with hyper kyphosis. Although respiratory alterations were observed, preserved core endurance may indicate early functional adaptation. Mean core muscle function was also higher in the healthy group, but differences were not statistically significant.

Increased thoracic kyphosis may alter trunk alignment, restrict chest wall movements, and change respiratory muscle coordination. This aligns with studies reporting associations between hyper kyphosis and altered respiratory function [23, 10]. Previous studies have reported that changes in thoracic posture can influence respiratory function by modifying thoracic structure and muscle activity [5,15,13]. Bastos et al. also reported an association between thoracic kyphosis angle and respiratory muscle performance, suggesting that spinal alignment may influence respiratory capacity [17]. Better abdominal and thoracic breathing patterns in the healthy group may be attributed to proper spinal alignment, better diaphragm function, and improved trunk muscle coordination. Breathing control interacts with core muscles via the diaphragm, abdominal muscles, and trunk stabilizers [20, 25].

Mohammadjabar and Gandomi reported that thoracic hyper kyphosis and related postural deviations were associated with changes in pulmonary function and musculoskeletal performance [26]. In addition, Hoffman et al. highlighted that abnormalities affecting the chest wall and musculoskeletal system may contribute to impaired ventilation and altered breathing patterns [16].

The lack of significant differences in core endurance indices may suggest that early-stage postural hyperkyphosis does not necessarily cause severe reductions in core muscle function, and respiratory changes may appear earlier. However, persistence of this condition over time could lead to further changes. Previous studies have emphasized the role of corrective and core strengthening exercises in controlling postural abnormalities [27, 28].

This study had several limitations. The research design does not allow causal conclusions regarding the relationship between thoracic hyper kyphosis and respiratory changes. In addition, Limitations include the limited amount of existing research, the inability to control participants' daily activities, individual differences, and the inability to control nutritional status.

Conclusions

Overall, the results indicate that postural thoracic hyper kyphosis in students may be associated with reduced quality of respiratory pattern. From a school health perspective, the findings highlight the importance of early screening of postural abnormalities among students. Therefore, spinal posture screening in schools, early identification of at-risk students, and corrective exercise programs focusing on breathing and core stability may help identify students at risk and support early intervention [29, 4]. Assessment of respiratory pattern in addition to postural evaluation may provide additional information regarding functional consequences of thoracic hyper kyphosis. Future studies should investigate the effects of various exercise programs with different intensities and durations on hyper kyphosis correction, core muscle function, and respiratory pattern changes, and compare results across age and gender groups.

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Authors, Contribution

Conflict of interest

None declared.

Ethical Permission

All stages of this research were conducted in accordance with the Declaration of Helsinki. All subjects expressed their full willingness to participate in the present research by filling out the informed consent form. All stages and processes of this research were approved by the Ethics Committee for Biological Research at Allameh Tabataba'i University with the code IR.ATU.REC.1402.017

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