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Relationship Between Physical Fitness Abilities, Trunk Range of Motion and Kyphosis in Junior High School Students

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Abstract: The purpose of the present research was to study the relationship between physical fitness abilities and the level of thoracic kyphosis in junior high school students. The subjects of the present research were 50 junior high school students with a mean and standard deviation of 13.32±0.95 years of age, 50.41±14.25 kg of weight and 155.51±9.38 cm of height, respectively. A Spinal Mouse was used to measure the spinal shape. The strength of erector spine muscles and scapular abductors was measured by a dynamometer. Flexibility of scapular flexors and spinal flexors was measured using the related tests. Descriptive statistics, Pearson correlation coefficient and stepwise multiple regression were applied in order to examine the relationship between the dependent variables and the independent variable at the 0.05 significance level. The results of Pearson correlation test indicated a significant relationship between thoracic kyphosis and all the predictor variables at $P \leq 0.05$. The results of multiple regression introduced three predictor models and in the third and most important model, strength of erector spine muscles (β = -0.38) and flexibility of trunk flexors (β = -0.26), flexibility of scapular flexors (β = -0.25) were found to be the most important predictors of variance in thoracic kyphosis ($F_{3,36}$ = 17.39, P<0.009, R^2 = 0.45). In conclusion, the results of the present research suggested that decrease in the strength of erector spine muscles and scapular abductors and also decrease in the flexibility of trunk flexors and scapular flexors may increase the level of thoracic kyphosis.

Key words: Kyphosis · Physical Fitness · Trunk Range of Motion

INTRODUCTION

Deviation from the natural posture is not only unbecoming on the outside, but also negatively associated with the efficiency of muscles and exposes the individual to musculoskeletal malformations and nervous disorders [1-3]. It has been reported that if the body is away from its natural position for a long time, it can lead to sustained muscle shortness or strain and finally to adaptation with this condition [1-4] and naturally this adaptation is known as strength and stiffness in shortened muscles and weakness and strain in the prolonged muscles [5]. Moreover, excessive use of a specific muscle group in a limited range of motion will also lead to muscular imbalance and undesirable postural changes [6-9].

Kyphosis is one of the one of the malformations of the upper spine and due to its prevalence, it has received much attention from researchers [2-4, 10, 11]. Kyphosis means excessive curvature of the upper spine. Despite the studies carried out on prevention and treatment of spinal abnormalities, no research has particularly dealt with the normal range of curvature of the spine and thus different research has studied different ranges. A possible reason could be factors such as age and gender, with research showing that the degree of kyphosis increases with age or that it increases faster in women than men [12]. Further, little increase in the curvature of the spinal column is not considered as a disorder, but when it increases excessively it will lead to disabilities, both in appearance and function, in both children and adults [13].

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A review of the literature showed that little research has been done on the relationship between kyphosis and strength/flexibility of trunk muscles. Meanwhile, studies have reported contradictory results. For instance, Holloway[14] reported that kyphosis could be due to weak dorsal trunk muscles and reduced flexibility of the anterior chest and shoulder musculature. Sinaki *et al*. [15] reported that erector spinae strength is negatively associated with kyphosis and a positively associated with physical exercise. Greendale *et al*. [16] studied the effect of yoga training on kyphosis and mentioned that strength training along with flexibility exercises improves kyphosis. Greig *et al*. [17] reported that kyphosis has a significant relationship with load on the spine, weakness of erector spine muscles, reduced physical exercise and increased fracture in vertebrae. Further, Egan and Sedlock [18] carried out a research on active and sedentary menopausal women and reported that although active women are stronger and more physically fit than sedentary women, this does not prevent kyphosis. The researchers found no association between kyphosis and back extensor strength and stated that important factors than muscle strength plays a role in kyphosis. Position of the body and the effect it has on different body organs including respiratory, circulatory and nervous systems is important. Most organ defects and structural weaknesses are not visible in childhood and this can cause malaise in adulthood that disturbs the natural activity of the body and even decreases lifetime [19-21].

Maturity is the time for the emergence of many postural abnormalities and at the same time the best period for correcting them. Despite the studies carried out in this regard, there is no clear evidence on whether there is an association between strength/flexibility of trunk muscles and kyphosis. Further, most of the studies have examined older individuals and it seems imperative to do a research on the youths due to the prevalence of this complication among this age group [18], so as to provide appropriate strategies for preventing the incidence and progress of such abnormalities. Thus, the purpose of the present research was to study the relationship between some physical fitness factors - including strength of scapular abductors and erector spine, flexibility of spinal flexors and ROM of scapular flexors - and kyphosis in male junior high school students.

MATERIALS AND METHODS

The present research is correlational. The subjects were 50 junior high school students from Shiraz with a respective mean and standard deviation of 13.32±0.95 years of age, 50.41±14.25 kg of weight and 155.51±9.38 cm of height and with a 27-60° angle of the vertebrae. A Spinal Mouse was used to measure the spinal shape. Before the test, the valuator explained the test procedures to the subjects. The subjects were instructed to take off their shirts and stand in front of the valuator with their normal posture. Then the valuator marked the neck of the subject with a felt-tip pen, placed the wheel of the Spinal Mouse on the seventh cervical vertebrae and moved down to the natal cleft of the subject. The data were transferred from the Spinal Mouse to the computer as radio-waves and the kyphotic angle of the backbones was identified.

For measuring the strength of erector spine of the subjects, first they warmed up for about 5 minutes and then they entered the test. Without bending the knees, the subject stood on the ergometer and the examiner adjusted the chain of the ergometer so that the handle of the device would be placed in the area in front of subject's thigh. Then, the subject was asked to hold the handle of the ergometer in a way that the right hand is turned inward and the left out is turned outward. At this point the subject was instructed to straighten their spinal column and pull the handle with maximum strength. The platform of the digital ergometer recorded the maximum generated force. After recording the maximum value, the subject was asked to rest for a minute and repeat the test. Finally the highest attempt of the subject was recorded as their erector spine strength.

For measuring the strength of scapular abductors, the subject was asked to hold the handles of the ergometer in their both hands and in front of the chest so that the arms were parallel to the ground. Then, they started separating the handles with maximum power. The ergometer recorded the maximum generated force. After resting and resetting the device, the test was performed again and their maximum record was considered as the strength of scapular abductors.

For measuring the flexibility of scapular flexors, the subjects lied prostrate on the ground and extended their hands above their head. After fixing their legs with the help of an assistant, the subject was given a ruler and instructed to hold it in both hands to the extent of their shoulder width. Then, with their face toward the ground, they were asked to raise the ruler as much as they can without lifting their head. This test was performed three times with a one-minute interval and the maximum record was considered as their score.

Table 1: Mean and standard deviation of the research variables

Research Parameters		Mean ± S.D.
Kyphosis		43.90 ± 7.30
Strength (N)	Back Extensors	93.20 ± 17.70
	Scapular Adductor	14.30 ± 5.60
Flexibility (cm)	Scapular Flexors	31.30 ± 8.00
	Trunk Flexors	35.50 ± 6.80

Table 2: The correlations between research parameters with kyphosis

	Strength		Flexibility	
Parameters	Back Extensors	Scapular Adductor	Scapular Flexors	Trunk Flexors
Correlation with Kyphosis	-0.55*	-0.46*	-0.50*	-0.46*

*significant at $P \leq 0.05$

For measuring the flexibility of spinal flexors, the subject lied prostrate on the ground, but this time they placed the palm of their hands on the back of their head without bending the elbows and after fixing their legs with the help of an assistant, they were asked to raise their upper trunk as much as they can and to the extent that the distance between the chin and the ground was measurable. This test was also performed three times and the maximum record was taken as their score.

The raw data were imported into SPSS 16 and descriptive statistics, Pearson's correlation coefficient and stepwise multivariate regression were applied for examining the relationship between the predictor variables and the criterion variable at the 0.05 significance level.

RESULTS

Mean and standard deviation of the research variables including kyphosis, strength of erector spine and scapular abductors and flexibility of scapular flexors and trunk flexors are presented in Table 1.

The correlations between research parameters with kyphosis are presented in Table 2. As can be seen, there is a significant difference between the criterion variable (kyphosis) and all the predictors (strength of erector spine and scapular abductors and flexibility of scapular flexors and trunk flexors) at the 0.05 significance level.

The relationship between the criterion variable (kyphosis) and all the predictors (strength of erector spine and scapular abductors and flexibility of scapular flexors and trunk flexors) was identified using multivariate regression at the 0.05 significance level and three predictor models were determined. In the third predictor model, R^2 was calculated to be 0.45, indicating that 45% of kyphosis variance is explained by the strength of erector spine, the flexibility of the trunk flexors and the flexibility of the scapular flexors. The adjusted R^2 that suggests the explanatory power of the model is -0.43 and this value is statistically significant ($F_{3,63}$ = 17.39, P = 0.09). The beta coefficient for the strength of erector spine in this model is -0.38 (P = 0.008). This indicates that the variation ratio of strength of erector spine to kyphosis is equal to -0.38. Moreover, the beta coefficient for the flexibility of the trunk flexors in this model is -0.26 (P = 0.011), indicating that the variation ratio of flexibility of the trunk flexors to kyphosis is equal to -0.26.Furthermore, the beta coefficient for the flexibility of the flexibility of the scapular flexors in this model is -0.25 (P = 0.024), indicating that the variation ratio of flexibility of the scapular flexors to kyphosis is equal to -0.25.

DISCUSSION AND CONCLUSION

The purpose of the present research was to study the relationship between certain physical fitness factors - including the strength of scapular abductors and erector spine muscles and the flexibility of scapular flexors and trunk flexors - and kyphosis in junior high school students. One of the findings of the research was the existence of an inverse relationship between the strength of erector spine muscles and kyphosis, suggesting that reduced strength of these muscles increases kyphosis. This finding is consistent with the results of some previous studies [15, 17, 22-24], but inconsistent with some others [18]. The compensatory changes in the curvature of the spine are caused by back muscles and they tend to maintain the position of the spinal column. Since displacement of the line of gravity occurs anteriorly or laterally to the spinal column, the slightest change in the line of gravity will lead to greater activation of the muscles in those areas (usually erector spine muscles). These are the first muscles responsible for maintaining the stability of the spinal column and if they are paralyzed, it will be impossible to maintain balance despite the function of ligaments and joints.

The negative relationship between kyphosis and strength of erector spine muscles can be justified by the reduced ability of these muscles for creating the necessary torque to maintain the upright position of the spinal column and the consequent inappropriate posture. With the decrease in the ability of this muscle to generate force in standing and seated postures, the spinal column is not sufficiently supported by the erector spine muscles, leading to the load and weight of the upper body on inactive organs (including ligaments, bones, cartilages, etc.). This loading can increase the length of erector spine muscles and lead to increased kyphosis [2, 3, 11, 23, 25]. The inconsistency of the results of previous research regarding the relationship between kyphosis and strength of erector spine muscles is probably due to the fact that previous research has been carried on elderly women with osteoporosis, while the present research studies junior high school students and besides studies have shown that erector spine strength decreases with age [19].

Another finding of the present research was the significant negative relationship between kyphosis and strength of scapular abductors. This suggests that kyphosis increases with decrease in the strength of these muscles. It seems that reduced strength of scapular abductors makes these muscles longer and they are not able to pull back the scapulae and shoulders, creating a position where the individual is always hunched and staying for a long time in such a position can increase the kyphotic angle. No similar research was found to have studied the relationship between scapular abductors and kyphosis.

The direction of the spinal column affects the position of scapula and both of these affect the function of the shoulder. The basis for such a relationship between the direction of the spinal column, the position of the scapula and function of the shoulder is at least related to two factors: (1) scapulohumeral rhythm: during the movement of the arm, the scapula must provide a stable support for the movements of the glenohumeral joint and at the same time move in relation to the humerus within the range of motion; (2) various muscular connections between the spinal column, scapula, clavicle and arm: the direction of these bones can directly change through the muscular connections between them, the direction of these bones affects the length of muscles and through this it can have an effect on muscle’s ability to generate tension. Serratus anterior, rhomboid major and rhomboid minor are the key muscles of scapular stabilization and help the movements of the scapula on the thorax [5]. The efficient activity of these muscles depends on the orientation of the scapula on the thorax and the length-tension relationship of scapular stabilizer muscles and humeral rotators [5]. Thoracic kyphosis leads to the downward rotation and anterior tilt of the scapula on the thorax and reduces its posterior tilt [5]. This kinematic change in the scapula which is itself due to the position of the spinal column will lead to shortness of upper trapezius muscle and anterior scapular muscles and the upper thoracic muscles as well as scapular retractors are put under tension [5]. This tension will weaken the scapular retractors. Thus the strong anterior muscles pull the scapula toward themselves and the scapula becomes protruded. In this position, the serratus anterior, rhomboid major and rhomboid minor pull the scapula forward and the rhomboid minor helps the anterior tilt and downward rotation of the scapula and the humeral bone turns inward [5]. This imbalance between scapular protractors and retractors which is due to the weakness of retractors on the one hand and shortness and strength of protractors on the other hand will lead to curved scapular position in kyphotic patients.

Another finding of the research was the significant negative relationship between kyphosis and the flexibility of back flexors and scapular flexors, indicating that reduction in the flexibility of these muscles increases kyphosis. The results of the present research are consistent with previous research [18, 20, 26, 27]. The major spinal flexors are abdominal muscles and the psoas major muscle where the proximal and distal ends of the abdominal muscles are mainly on the lower ribs and on the pelvis. Short abdominal muscles will shorten the distance between the lower ribs and the pelvis and the spinal column faces difficulty for extension and hyperextension from the lumbar area, thus losing its ability for performing such movement in its natural range of motion. Moreover, the proximal and distal ends of the psoas major muscle are on the pelvis and thigh. In spinal extension and hypertension, it is necessary that the pelvic-thigh muscles including psoas major muscle are prolonged in the natural range of motion; shortening of psoas major muscle, the ability of this muscle for moving in the entire range of motion will naturally decrease and it prevents the extension and in particular hyperextension, of the spinal column. Generally, it can be conceived that decrease in the flexibility of spinal flexor muscles and especially abdominal muscles will lead to kyphotic spinal column in standing and seated postures. Maintaining such a position will in long term lead to excessive curvature of the spinal column.

CONCLUSION

Considering the results of the research, it can be suggested that reduced strength of trunk extensors and shoulder abductors and reduced flexibility of trunk flexors and scapula flexors increase the level of kyphosis in junior high school students. Thus, teachers of physical education and sports science must increase the strength and flexibility of these muscles in order to prevent the incidence and prevalence of the complications of this malformation in students.

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