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Original Article

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The Effect of Inspiratory Muscle Training on the Thoracic Spine Curve, Inspiratory Volume and Cardio-Respiratory Endurance in Boys with Hyper-kyphosis

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Abstract

Background: *Hyper-kyphosis is one of the most common malalignments in adolescent boys and can affect their breathing. Inspiratory muscle training (IMT) may improve the function of the respiratory muscles in adolescents and may influence their skeletal structure as well. So, this study aimed to examine the effects of inspiratory muscle training on the thoracic spine curve, inspiratory volume and cardio-respiratory endurance in hyperkyphotic boys*

Methods: *This study was a semi experimentally in design, pre and post-test design with a control group. Twenty-two 12-15 boys, with thoracic spine curve more than 49 degrees were randomly divided into control and experimental groups. Both groups performed the same corrective exercise for hyper-kyphosis, the experimental group also performed inspiratory muscle training five days a week using the power breathing device, based on the training protocol. Both groups were evaluated before and after 12 weeks of training in terms of the thoracic spine curve, inspiratory volume, S-index, PIF, and cardio-respiratory endurance.*

Results: *The data analysis showed that the thoracic spine curve decreased significantly in the IMT group (Pvalue=0.025). The IMT group showed significantly increase in inspiratory S-index (T=4.058, Pvalue=0.002), PIF (T=4.06, Pvalue=0.002) and cardio-respiratory endurance (T=2.62, Pvalue=0.050) at posttest in compare to control group.*

Conclusions: *Based on the study findings, it can be concluded that respiratory muscle strengthening alone may not be by itself sufficient for the improvement of Hyper-kyphosis, and corrective exercises can also be recommended along with it.*

Keywords: Inspiratory muscle training, Hyper-kyphosis, Inspiratory volume, Cardio-respiratory endurance.

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Introduction

Hyper-kyphosis is one of the spine deformities in the sagittal plane. It may occur in both young and adult; girls and boys. That is more popular in adults and young girls. The normal rate of kyphosis is 20-40 degrees. The spin thoracic curve more than 40 degrees, it is considered an abnormality. There are two types of functional and structural hyper-kyphosis; Functional variants can be modified by corrective exercise and crests, and construction types may require surgery.[1,2] This deformity may due to pain.[3] Also, hyper-kyphosis limits rang of upper limb mobility and reduces chest stretching rang. Other researches show that breathing criteria are lower in those with hyper-kyphosis.[4]

Some of the studies suggest that inspiratory muscle training (IMT) can improve sports performance through mechanisms for decreasing dyspnea, reducing respiratory effort, increasing inward flow, increasing inward muscle strength, and attenuating metabolic reflection.[5-8] Also, these practices maintain and achieve an athlete's maximum performance.[9]

Exercise and strengthening inspiratory muscle training increase the maximum power of inspiratory muscles and this increases the tidal volume, reduces the number of breathing during exercise, and increases the maximal inspiration flow and ultimately improves athletic performance.[10] McConnell, who is a pioneer in using IMT technique, displays that training with power breath increase inspiratory muscle power up to 30-50 percent just with 2 times a day, each time 39 breath[10] also, it has been shown that IMT can increase inspiratory capacity and improves cob angle in a patient with idiopathic scoliosis.[6]

As discussed, hyper-kyphosis can decrease breathing capacity and IMT in addition to improving inspiration capacities, change performance too. So, this study designed to survey the effects of inspiratory muscle training on the thoracic spine curve, inspiratory volume and cardio-respiratory endurance in boys with Hyper-kyphosis.

Materials and Methods

This is semi-experimental study with pre and post design. The sampling method was a systematic clustering design. First of all, 3 high schools in the Najafabad city were selected based on the geographic location; by referring to these schools and observing about 750 students and using the chessboard, 60 students with kyphosis were identified by the New York method (r=0.89).[11] The including criteria were being 12-16 years old, thoracic spine curve more than 49 degree12 that was measured using a flexible ruler (r=0.93). For further validation, the measurements were repeated three times and the mean angles obtained were calculated. Then, from the qualified subjects, 22 boys were selected and matched based on the kyphosis angle then randomly divided into experimental and control groups through a simple randomization method. The excluding criteria were having back pain, any cardiovascular disease such as high blood pressure, history of angiography, any type of heart surgery, cardiac arrhythmia, pacemaker use, etc., no respiratory allergies, asthma or any disease that impedes severe respiratory activity in individuals. Also, they were without other postural abnormalities affecting the research process such as hyper-lordosis, scoliosis, and stenosis.

Demographic data including age, height, weight, and BMI were measured 2 days before the training and in the pre-test phase. Then, the inspiratory volume was measured by power breath than at the same time on a different day, the VO_2max maximal oxygen consumption test was performed on the subjects in both groups by a 20 m dual shuttle run test. Their Vo_2max estimated by this formula:[12] $Vo_2max=6\times(speed)-27.1$

The thoracic curve was asses' trough Judas method and the angle of kyphosis estimated by this formula:[12] $\theta=4[ARCtag(2H/L)]$.

Subsequently, the participants were briefed on how to perform respiratory muscle training; after ensuring that the experimental group received the necessary training, this group underwent inspiratory muscle training for 12 weeks. They were equipped with a power breathe device and both groups performed same corrective exercises. Twenty-four hours after the last training session, all pre-test materials in both experimental and control groups were re-measured using the same methods and the same time by the pre-test.

In this study, a digital inspiratory muscle training device (power breathe KH1 inspiratory meter; Gaiam), and mechanical power breathe devices were used to perform inspiratory muscle training (figure 1).[13] The Strength index of inspiration (S-index), power of inspiration flow (PIF) and inspiratory volume measurement test was performed for all subjects in the experimental group weekly, by a digital device. Every subject had 5 inspirations through a digital device. The best record of S-index was compared with the Fitness level of table 1 and the mechanical device was fitted based on the protocol (table 2). The validity of this device has been estimated 0.97 for average mean inspiratory power.[14]

The inspiratory muscle training program was performed for 12 weeks, five days a week, for 30 minutes each day, by the experimental group, under the supervision of the tester. Then the subjects fastened a nose pad in a comfortable position and breathed through mechanical power breath by their mouth. The inspiratory muscle training protocol used in the study presented in table 2.[15]

Figure 1. Mechanical power breathe device

The research data were analyzed at descriptive and analyzing levels. In the descriptive statistics section, central tendency indices such as mean, median and mode, and dispersion indices such as standard deviation, variance, range of scores changes, and related graphs were described to collect information and to test the research hypotheses, the inferential statistical methods were used. Data were analyzed using the independent T-test for comparison between groups and paired sample T-test for intergroup changes (Pvalue<0.05). All statistical calculations were performed using SPSS, version 22. The significant level was set at 0.05.

Table 1. Manual of equality of load and levels of the power breathe device

Model	Load ($-cmH_2o$)								
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Level 9
Power breath classic for fitness	10	30	50	70	90	110	130	150	170

Table 2. The protocol of inspiratory-muscle training

	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week
Intensity	10%	25%	45%	65%	65%	65%	65%	65%
Breath rate per day	30	60	60	60	60	90	90	90

Results

The general statistical information on the demographic characteristics of the subjects is shown in table 3.

As we can see in table 3, there are not any significant differences between groups in age, height, and weight at baseline. The results of inter group and intra group analysis of thoracic spine curvature and estimated VO_2max in pre and posttest are presented in table 4.

As the table 4 shows, thoracic spine curvature was significantly reduced in IMT group in post-test (T=2.63; Pvalue=0.025) but the control group didn't display any significant changes (T=0.456; Pvalue=658). On the other hand, groups any significant differences in per test (T=0.705; Pvalue=0.486) or post-test (T=1.11; Pvalue=0.280). In shuttle run test, both groups performed better in post-test than pretest, that it displays significant changes in their estimated VO_2max (IMT: T=6.708; Pvalue=0.000; control: T=2.39; Pvalue=0.038). Also, groups didn't show significant differences in their estimated VO_2max at baseline (T=0.262; Pvalue=0.769), however the experimental group significantly performed better at posttest (T=2.062; Pvalue=0.050). These findings are similar to those for S-index (Pretest: T=0.9; Pvalue=0.929; Posttest: T=3.832; Pvalue=0.001) and PIF (Pretest: T=0.151; Pvalue=0.882; Posttest: T=3.92; Pvalue=0.001) and inspiratory volume (Pretest: T=0.281; Pvalue=0.781; Posttest: T=2.34; Pvalue=0.03) (table 5).

AThe IMT group showed significant improvement in S-index (T=4.058; Pvalue=0.002) and PIF (T=4.06; Pvalue=0.002) in posttest. Despite of that there were not any significant improvement in inspiratory volume in posttest (T=1.782; Pvalue=0.105). The control group didn't show any significant changes in S-index (T=0.341; Pvalue=0.741); PIF (T=0.229; Pvalue=0.771) nor volume of inspiration (T=0.241; Pvalue=0.815) (table 5).

Table 3. General statistical information on the demographic characteristics of the subjects based on Independent T-test.

Factor	Group	Mean±SD	T	Pvalue
Age (years)	Experimental	14.1±1.52	0.95	0.29
	Control	13.93±1.62		
Height (centimeters)	Experimental	177.5±5.12	1.791	0.089
	CONTROL	172.36±8.11		
Weight (kilogram)	Experimental	72.27±15.10	1.706	0.106
	Control	63.09±9.50		

Table 4. Results of the analysis of thoracic spine curvature and Cardio-inspiratory endurance factors based on independent T-test (Intra group) and paired sample T test (Inter group).

Factor	Group	Pre-test Mean±SD	Post-test Mean±SD	Inter-group (1,10) Df
Thoracic spine curvature	IMT	57.86±6.63	48.03±12.49	T=2.63; P=0.025*
	Control	55.89±6.4	53.89±12.27	T=0.456; =0.658
	Intra-group (1,20) df	T=0.705; P=0.489	T=1.11; P=0.280	
Cardio-inspiratory endurance (estimated VO_2max)	IMT	33.72±5.2	41.08±5.03	T=6.708; P=0.000*
	Control	34.26±4.5	36.45±5.5	T=2.39; P=0.038*
	Intra-group (1,20) df	T=0.262; P=0.769	T=2.062; P=0.050*	

*. significant changes at α≤0.05 level.

Table 5. Results of the analysis factors based on Independent T-test (Intra group) and Paired sample T test (Inter group) for S-index, PIF and inspiratory Volume.

Factor	Group	Pre-test mean±SD	Post-test mean±SD	Inter-group (1, 10) Df
S-index	IMT	55.16±19,2	84.6±20.2	T=4.058; P=0.002*
	Control	54.3±25.01	52.44±19.23	T=0.341; P=0.74
	Intra-group (1,20) df	T=0.90; P=0.929	T=3.823; P=0.001*	
PIF	IMT	3.14±1.15	4.83±1.08	T=4.06; P=0.002*
	Control	3.06±1.48	2.96±1.13	T=0.229; P=0.771
	Intra-group (1,20) df	T=0.151; P=0.882	T=3.92; P=0.001*	
Volume	IMT	2.48±0.66	2.9±0.37	T=1.782; P=0.105
	Control	2.38±0.96	2.34±0.7	T=0.241; P=0.815
	Intra-group (1,20) df	T=0.281; P=781	T=2.34; P=0.03*	

*. significant changes at α≤0.05 level

Discussion

The results showed that the 12-weeks inspiratory muscle training (IMT) had a significant effect on the inspiratory volume, S-index and PIF of boys with hyper-kyphosis (table 5). These findings were similar to the results of Roemer et al.[16], Haji Hasani et al., and Memari et al.[17]. One of the reasons that the results of this study are consistent with those of this hypothesis is their use of similar inspiratory muscle training and the same duration of the training, as well as similarity of the subjects in terms of age and sex.

Despite findings in this study, Behpour et al found that inspiratory muscle training had no significant effect on the inspiratory function of the experimental group. Factors such as sex and age of the samples, occupation, use of different tools, and differences in the subjects' training protocols are the reasons of this difference results.[18]

In the other hand, the results of this study showed that 12 weeks' inspiratory muscle training (IMT) had a significant effect on cardiorespiratory endurance in the boys with hyper-kyphosis and improved their estimated Vo_2max in posttest than pretest and in comparison with control group (Pvalue=0.050); other researches reports same findings too.[3,18,19]

The mean of thoracic spine curvature angle in the experimental group was significantly decreased after 12 weeks of IMT training (Pvalue=0.025).

The results of this study were not in agreement with those of Memari et al., showing the no significant effect of respiratory muscle training on the kyphosis angle.[17] It may be occurring because of longest period of training in this study.

According to the research by Jensens et al., inspiratory muscle training improves the intensity of low back pain in non-specific low back pain patients and strengthens the central muscles of the body, including the diaphragm;[20] Power breathe, as a device that strengthens against inspiration, uses a training principle called "resistance training", that is similar to strengthening the muscles of the limbs using weights, that is performed by resistance training with dumbbells. Therefore, the pressure created by the breath on the inspiratory muscles, such as the diaphragm muscle, the intercostal muscles, and so on will strengthen those muscles.

To explain the results of this study, it can be discussing that IMT is able to improve the volume of inspiration and significantly increases the VO_2max in boys with hyper-kyphosis also it can significantly correct the angle of the thoracic curve of boys with hyper-kyphosis. This study suggests IMT be a part of the hyper-kyphosis corrective exercises program to strengthening inspiratory muscles and improving cardio-respiratory endurance in the boys with hyper-kyphosis or be a replacement for those hyper-kyphotic boys that are not able to take part in corrective exercises programs.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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