Effect Of Thoracic Spine Manipulation on Pulmonary Function Tests in Asymptomatic Postural Kyphosis

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ABSTRACT

Background: *Postural Kyphosis is a common flexible deformity of spinal curvature which is not associated with any underlying bony abnormality.* ***Purpose:*** *This study examined the effect of thoracic spine manipulation on pulmonary function tests in Asymptomatic postural kyphosis.* ***Methods:*** *Thirty-four subjects with postural kyphosis aged 20 to 30 years, both sexes, had a thoracic kyphotic angle between 40 and 60 degrees. They were randomly allocated into two equally matched groups (A and B). Group A received thoracic spinal manipulation plus traditional physiotherapy program (core stability exercises and postural correction), 3 times/week for 6 weeks, manipulation delivered once weekly. Group B received only the traditional physiotherapy program for 3 times/week for 6 weeks. The following tests were conducted twice: once prior to treatment and once after, kyphotic index (KI), axillary chest expansion, 4th rib chest expansion, Xiphoid chest expansion, Forced Vital Capacity (FVC), Forced expiratory Volume at 1st second (FEV1), FVC/FEV1 ratio and estimated maximal oxygen consumption.* ***Results:*** *The findings revealed that thoracic manipulation was successful to decrease KI and increase axillary chest expansion, FVC and FEV1 of group A compared to that of group B ($p < 0.05$). On the other hand, no significant differences were observed between groups in 4th rib chest expansion, xiphoid chest expansion, FVC/FEV1, and VO2 max between groups after intervention ($p < 0.05$).* ***Conclusion:*** *Exercise regimens that involve thoracic manipulation for asymptomatic postural kyphosis was more beneficial than traditional intervention alone in terms of pulmonary capacity.*

Key words *:Postural Kyphosis, thoracic manipulation, pulmonary function.*

INTRODUCTION

Thoracic kyphosis is the convex curvature that appear in the sagittal plane of the thoracic spine and is measured by Cobb’s angle. Thoracic hyperkyphosis was defined as a thoracic kyphosis angle greater than 40◦.(Zappalá et al., 2021)

Hyperkyphosis restricts the range of motion of the rib cage, the amount of chest expansion, and the capacity of the lungs to expand. Individuals with more advanced kyphosis might ׀ have a faster deterioration in pulmonary function (Lorbergs et al., 2017). Poor posture leads to postural kyphosis, also referred to as round back. Young adults and adolescents are more likely to suffer from this posture disorder because they often slouch while standing and sitting, which causes the backbone to bend forward, postural kyphosis typically develops gradually and it affects girls more often than boys (Abd-Eltawab & Ameer, 2021)

Slouching or poor posture can lead to abnormal vertebral bone growth as well as Abnormal stretching of the spinal ligaments (Hanfy et al., 2012)

Effective pulmonary ventilation is necessary for optimal pulmonary function. the term "pulmonary ventilation" describes how air enters and exits the lungs. The mechanical movements of the thoracic cage, diaphragm, and thoracic spine result in chest expansion, which is the primary factor controlling pulmonary ventilation ((Joo and Yoo, 2019).

Movement of the thoracic spine is coupled with movement of the adjoining rib. Thoracic extension involves concurrent posterior rotation (external torsion) and depression of the posterior ribs with elevation of the anterior ribs. Although difficult to separate thoracic spine motion from the movement of surrounding structures. Restrictions in motion have the potential to impact performance and may manifest as local or distant musculoskeletal pathology. (Johnson & Grindstaff, 2012)

Increasing kyphosis severity's impact on declining pulmonary function could be attributed to restrictive ventilatory impairment brought on by a smaller thoracic volume. Additionally, when the anterior curvature of the thoracic spine rises and posture becomes more slumped, there is less mobility in the thoracic rib cage, which restricts the expansion of the thoracic and lung cavities during a maximal inspiratory maneuver (Lorbergs et al., 2017)

To keep up with the latest technological developments, most people, using mobile devices excessively which has become a daily and essential necessity. However, it's important to keep in mind that extended cell phone use has been linked to musculoskeletal problem symptoms (Balakrishnan et al., 2016)

Many illnesses are influenced by incorrect sitting positions, but it particularly affects how well the respiratory system functions. According to the majority of authors, maintaining the spine's natural curvature is essential for proper sitting biomechanics, head alignment, and pelvic posture. It increases awareness of risks associated with the workplace and introduces instruction on the fundamentals of appropriate sitting posture .(Szczygieł et al., 2017)

The postural correction reflected by reduction of KI was effective to improve dyspnea index and pulmonary function in COPD patients and hence their overall quality-of-life.(Gaude et al., 2014)

Thoracic kyphosis and protracted shoulder have a direct effect on upper back and scapular muscle length and reach by the intervertebral joints to its end range.

Therefore, the sustained strain on these soft tissues may lead to upper back pain in skeletal muscles, prolonged contractions, and muscle shortening which impede proper blood flow. Maintaining good posture permits and improves circulatory recovery by giving muscles time to rest between contractions which permits and facilitates recovery of circulation. Despite the fact that there is a large variety of postures, therapists should take into account the best posture for each patient and tailor their exercise regimens instead of concentrating on a perfect posture that works for everyone. Maintaining a proper upright trunk posture can alter the range of motion, symptoms, and muscle activation (Egan et al., 2011)

combination of Post isometric facilitation with other therapy modality and to compare the effect of Axillary Phonophoresis or Post isometric facilitation with active control group in the management of Adhesive Capsulitis. (11). So, this research was conducted to focus on the comparison between the effect of Axillary Phonophoresis and Post isometric facilitation in reducing pain and improving shoulder functional activities in patients with Adhesive Capsulitis.

MATERIAL AND METHODS:

2.1.: Subjects:

Thirty-four subjects from the outpatient clinics, Matai Central Hospital, in Alminia, Egypt, all have postural kyphosis in which thoracic kyphotic angle (TKA)exceed 40 degrees, took part in the study. These people were divided into two groups with the same number.

• Group A got 6 weeks of thrice-weekly traditional physiotherapy program (core stability exercises and postural correction) plus thoracic spinal manipulation which delivered once weekly considering hypermobility issue

• Group B got 6 weeks of thrice-weekly only traditional physiotherapy program

Participants who met the following requirements were included in the study:

There are a total of 34 subjects in the trial, about 20– 30 years old, TKA or modified cobbs angle between 40 degrees, The research included subjects of both sexes, females subjects are nulliparous, they are who were not taking any medication then for a respiratory condition and had no pain in the thoracic region.

Individuals with any contraindications to spinal manipulation even relative or absolute, any subject who had vascular complication e.g.: aneurysm, tumors or traumatic injuries, Past medical history included conditions that may have influenced the provision of physiotherapy interventions such as (severe asthma, chronic airflow limitation, bronchiectasis, ankylosing spondylitis), smokers, Post abdominal and thoracic surgeries, musculoskeletal problems that may interfere with thoracic region and Patients previously diagnosed with chest disease were excluded from the study.

2.2.:Tools:

A-Evaluation tools:

1. Spirometry: portable digital spirometer (Spirobank , MIR, UK,) was used to measure FVC, FEV1 as well as FEV1/FVC, Participants used a nose clip to conduct forced breathing exercises at least five times and no more than eight times, until variability was within 5% for 3 successive maneuvers, at which point the highest score was recorded.

2. flexible ruler : (Brand: ATI Flexible Curve Ruler- 60 Cm) was used to obtain measurements of thoracic kyphotic angle

before and after treatment in the sagittal plane, its a 60 cm long and 2 cm wide, which bends in one plane only and can maintain a temporary fixed shape that can be transferred to paper.

3. Measuring tape: to assess the chest expansion .The tape is a fiber-glass ribbon with linear measurement markings; graduation every 1 millimetre with a total length of 150 cm.

4. weight – Hight Scale : to calculate BMI and assessment of participants, according to the equation BMI = body weight divided by height squared (kg/m2) (Faerstein & Winkelstein Jr, 2012)

5. Assessment of physical performance by cooper run/walk test(CRT), assessment of Predicted maximum oxygen uptake capacity (PVO2max), total distance (in kelometers) covered in 12 min was measured and the following equation was used to predict the estimated VO2max.

VO2max (ml·kg-1 ·min-1) = (22.351 x distance covered in kilometres) - 11.288 (Bandyopadhyay, 2015)

B) Treatment tools:

No tools as maneuver will performed manually by therapist hands and body

2.3 Treatment procedure:

Before taking part in the trial, every patient had to complete an informed consent form. The research was conducted from August 2023 to December 2023. They were given the single instruction to "leave your arms by your sides and face the wall" (which was approximately 1.5 m in front of the participant), which confirmed that their thoracic kyphosis angles were more than 40 degrees and less than 60 degrees when they stood upright on a bubble inclinometer. The measurement was taken using a gravity-dependent (analogue) bubble inclinometer (Base- line bubble inclinometer, idass,CE 12-1056). The bubble inclinometer was zeroed on a vertical wall before measurements were taken because it is gravity-dependent. Following a typical clinical protocol, as described by(Clarkson, 2013) The C7 spinous process's pencil mark was where the inclinometer's cephalic foot was initially positioned. The lower thoracic spine underwent a repeat of this technique, with the inclinometer's caudal foot positioned on the pencil mark designated for T12.Making sure the recorder's eyes were on the same horizontal plane as the inclinometer allowed us to minimize parallax error in each measurement of the two inclinometer angles. The difference between the two readings was used to calculate the thoracic kyphosis measure from the inclinometer data.

Group A:

Each patient participated in a thrice supervised weekly exercise program

1. Warming up phase:

a. Diaphragmatic breathing exercise from crock lying position.

b. Posture correction exercises: Posture correction exercise from sitting

2. Stretching exercise:

a. Pectorals major muscles stretching from sitting position.

b. Hip flexors stretching from standing position.

3. Thoracic spine manipulation, the participants were told to lie on their backs with their arms crossed over their chests in a supine position. The therapist placed a pistol-grip stabilizing hand in place. In order to optimize the impact on chest wall rigidity, the thoracic spinal manipulation component was limited to the thoracic area and included

both high-velocity and low-amplitude (HVLA) procedures.

4. Thoracic spine mobilization exercises

a. Scapular Retraction Holds In Prone Lying

b. Upper thoracic extension from relaxed prone lying with scapular retraction.

5. Core stabilization exercises included the curl-up, side bridge, trunk extension, double-leg lifts, and bird-dog exercises, which support respiratory functions. The intensity of the training was gradually provided in the form of increased duration and frequency (sets, repetitions, and contraction time), increasing the complexity of the exercises (adding opposite limb movements) and increasing the lever arm of the exercises. The rest between sets was similar 60 seconds., and an additional 2 to 3 minutes rest was provided between exercises

6. Cooling down phase for 5 minutes. Include diaphragmatic breathing from crock lying position

7. Advices for good posture:

a. Ideal sitting position on a stool.

b. Ideal standing position.

c. The right way of lifting a weight.

Group B:

The control group performed the previous exercise regimen except they didn't receive the manipulation thrust.

RESULTS

- *Subject characteristics*:

Thirty-four patients with postural Kyphosis participated in this study. Table (1) shows the subject characteristics of group A and B. There was no significant difference between groups in age, weight, height, BMI and sex distribution (p > 0.05).

Table 1. Basic characteristics of participants.

	Group A	Group B	MD	t- value	p-value
	Mean ± SD	Mean ± SD			
Age (years)	23.41 ± 2.03	24.53 ± 1.91	-1.12	-1.65	0.11
Weight (kg)	64.91 ± 15.92	65.35 ± 12.20	-0.44	-0.09	0.93
Height (cm)	168.83 ± 9.49	168.88 ± 9.49	-0.05	-0.02	0.99
BMI (kg/m²)	22.43 ± 3.16	22.67 ± 1.99	0.24	-0.26	0.79
Sex, n (%)					
Females	8 (47%)	5 (29%)		χ^2 = 1.12	0.29
Males	9 (53%)	12 (71%)			

SD, standard deviation; χ^2, chi squared value; p-value, level of significance

Effect of treatment on KI, axillary chest expansion, 4th rib chest expansion, xiphoid chest expansion, FVC, FEV1, FVC/FEV1 ratio and VO2 max:

Two-way mixed MANOVA revealed that there was a significant interaction of treatment and time ($F = 21.49$, $p = 0.001$). There was a significant main effect of time ($F = 67.08$, $p = 0.001$). There was a significant main effect of treatment ($F = 3.19$, $p = 0.01$).

Within group comparison

There was a significant decrease in KI and a significant increase in axillary chest expansion, 4th rib chest expansion and xiphoid chest expansion of group A and B post treatment compared with pretreatment ($p < 0.01$). The percent of change of KI, axillary chest expansion, 4th rib chest expansion and xiphoid chest expansion of group A was 20.55, 36.31, 32.46 and 27.83% respectively and that in group B was 7.12, 8.08, 21.37 and 17.58% respectively. (Table 2).

There was a significant increase in FVC, FEV1, FVC/FEV1 and VO2 max of group A post treatment compared with pretreatment ($p < 0.001$). There was a significant increase in FEV1 and VO2 max of group B post treatment compared with pretreatment ($p < 0.05$), while there was no significant change in FVC and FVC/ FEV1. The percent of change of FVC, FEV1, FVC/FEV1 and VO2 max of group A was 10.57, 16.99, 5.45 and 8.91% respectively and that in group B was 1.55, 2.88, 1.23 and 7.99% respectively. (Table 3).

Between group comparison

There was no significant difference between groups pre treatment ($p > 0.05$). There was a significant decrease in KI and a significant increase in axillary chest expansion, FVC and FEV1 of group A compared with that of group B post treatment ($p < 0.05$).

There was no significant difference in 4th rib chest expansion, xiphoid chest expansion,

FVC/FEV1 and VO2 max between groups post treatment ($p < 0.05$). (Table 2-3).

Table 2. Mean KI, axillary chest expansion, 4th rib chest expansion and xiphoid chest expansion pre and post treatment of group A and B:

	Pre treatment	Post treatment			
	Mean ±SD	**Mean ±SD**	**MD**	**% of change**	**p value**
KI (%)					
Group A	11.59 ± 0.74	9.21 ± 1.35	2.38	20.55	0.001
Group B	11.66 ± 0.94	10.83 ± 0.82	0.83	7.12	0.001
MD	-0.06	-1.62			
	p = 0.83	***p = 0.001***			
Axillary chest expansion (cm)					
Group A	5.26 ± 0.85	7.18 ± 1.20	-1.91	36.31	0.001
Group B	5.17 ± 1.21	5.59 ± 1.23	-0.42	8.08	0.01
MD	0.09	1.59			

	p = 0.79	***p = 0.001***			
4th rib chest expansion (cm)					
Group A	5.62 ± 1.35	7.44 ± 1.76	-1.82	32.46	0.001
Group B	5.75 ± 1.64	6.98 ± 1.57	-1.23	21.37	0.001
MD	-0.14	0.46			
	p = 0.8	***p = 0.42***			
Xiphoid chest expansion (cm)					
Group A	6.24 ± 1.86	7.97 ± 1.87	-1.74	27.83	0.001
Group B	6.36 ± 2.14	7.48 ± 1.91	-1.12	17.58	0.001
MD	-0.12	0.49			
	p = 0.86	***p = 0.45***			

SD, Standard deviation; MD, Mean difference; p value, Probability value

Table 3. Mean FVC, FEV1, FVC/FEV1 and VO2 max pre and post treatment of group A and B:

	Pre treatment	**Post treatment**			
	Mean ±SD	**Mean ±SD**	**MD**	**% of change**	**p value**
FVC (L)					
Group A	4.72 ± 0.77	5.22 ± 0.71	-0.50	10.57	0.001
Group B	4.51 ± 0.92	4.58 ± 0.89	-0.07	1.55	0.16
MD	0.21	0.64			
	p = 0.48	***p = 0.02***			
FEV1 (L)					
Group A	3.85 ± 0.55	4.50 ± 0.57	-0.65	16.99	0.001
Group B	3.68 ± 0.63	3.79 ± 0.62	-0.11	2.88	0.04
MD	0.17	0.71			
	p = 0.41	***p = 0.001***			
FVC/FEV1 (%)					
Group A	82.01 ± 7.11	86.48 ± 5.88	-4.47	5.45	0.001
Group B	82.12 ± 5.12	83.13 ± 4.77	-1.01	1.23	0.08
MD	-0.11	3.35			
	p = 0.95	***p = 0.07***			
VO2 max (mL/kg/min)					
Group A	25.64 ± 5.88	27.92 ± 5.7	-2.28	8.91	0.001
Group B	24.56 ± 4.14	26.52 ± 4.7	-1.96	7.99	0.001

MD	1.08 ***p = 0.54***	1.41 ***p = 0.43***

SD, Standard deviation; MD, Mean difference; p value, Probability value

DISCUSSION

The current work compared the effects of thoracic spine manipulation, core stability exercises and postural correction on postural Kyphosis. The manipulative techniques and exercises aimed to induce therapeutic effects by increasing thoracic mobility, increasing chest dimensions, increasing pulmonary function measures, increasing aerobic fitness and restoring normal thoracic kyphotic angle. For this purpose, we measured the changes in pulmonary function tests (FVC, FEV1, FEV1/FVC), kyphotic index, chest expansion and aerobic fitness in subjects with postural Kyphosis.

For many years, the main goals of spinal manipulation have been to reduce functional impairment, improve range of motion, and relieve joint restriction. (Waqas et al., 2023) . spinal manipulative treatments were also believed to elicit reflex reactions in the muscles beneath the treated area which recorded by EMG, That reflex influences places far from the actual treatment site and is not always localized.(Herzog, 2010)

In literature Variations in the distribution of kyphosis in a population without symptoms indicate that TK is not a clear circular arc: when TK is low, two thirds of the kyphosis is found in the upper region, and when TK rises, the distribution of kyphosis will be symmetric with regard to T7.(Lafage et al., 2020)

Additionally, at the level of the fifth thoracic vertebra, which is recognized to have SNS pre-ganglionic neurons and that why in this study manipulation was focused to upper and middle regions.(Sampath et al., 2017)

The finding of the present study showed that: According to research by (Shin & Lee, 2016), thoracic spinal manipulation has been shown to improve respiratory function (FVC and FEV1) by increasing thoracic joint mobility, it has also been suggested that manipulation therapy stimulates autonomic activity, which in turn causes vasodilation, smooth muscle relaxation, and increased blood flow, which in turn results in changes in the tissue and/or improved range of motion. It would make sense to think of manipulation therapy as an additional therapeutic strategy to improve thoracic mobility and minimize breathing effort.

There is experimental evidence that pri mary afferent neurons from paraspinal tissue s and the motor control system are affected b y spinal manipulation.(Pickar, 2002)

On the other hand, study trials that differs from these results and support clam of non changeable effect on sympathetic nervous system activity following manipulation, was conducted as specific for T3 and T4 which confirm a balance between the sympathetic and parasympathetic nervous system activity (Sillevis et al., 2010), where the study conducted by(Sampath et al., 2017) in which manipulation was targeting upper and Middle thoracic region and match the manual intervention in this study support that following thoracic spinal manipulation a pattern of rapid sympathetic excitement was also noticed.

In terms of chest expansion, the results of this study agree with those of a study by

(Maji et al., 2018) which found that thoracic spine thrust manipulation significantly affected chest expansion and enhanced lung function measures, These findings were further corroborated by (Waqas et al., 2023) who verified that thoracic exercises alone were not as effective in improving chest expansion or thoracic range of motion as spinal manipulation and exercise combined were.

A significant increase in axillary chest expansion was noticed in study group compared with that of control group post treatment which can be attributed to targeting mainly the upper and middle thoracic regions by the force of manipulative thrust.

CONCLUSION

Exercise regimens that involve thoracic manipulation for asymptomatic postural kyphosis was more beneficial than traditional intervention alone in terms of pulmonary capacity. By the end of 6 week of follow up, not only FVC that shows significant improvement but also FEV1 which reflect the benefits of thoracic manipulation either in targeting restrictive or obstructive disorders.

Keywords: Postural Kyphosis, thoracic manipulation, pulmonary function.

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Disclosure statement

The research did not involve any financial interest or benefits for the author.

Conflict of interest

The authors have declared that they do not have any conflict of interest.

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