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Sagittal postural assessment and lung function in physical therapy students: correlation study

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Abstract:

Objective: This study investigated the correlation between thoracic spine sagittal mobility and lung function among physical therapy students.

Material and methods: A total of forty-six students from Deraya University ages ranged from 19-24 years were enrolled in one group to study the correlation between sagittal spinal variability in the thoracic region and lung function among physical therapy students by using a Spinal Mouse device to measure the thoracic spine sagittal mobility and spirometer device to assess lung function (forced expiratory volume FEV & forced expiratory volume / forced vital capacity FEV1/FVC).

Results: There was a moderately negative correlation between FVC, FEV1, and posture from the fixed neutral position (r = -0.643, p = 0.001) and (r = -0.570, p = 0.001) respectively but was not significantly correlated with posture from neutral to flexion or neutral to extension. The correlation between the FEV1/FVC and posture was moderately negatively correlated with posture during movement from neutral to flexion (r = -0.322, p = 0.029) but not significantly associated with posture from neutral to neutral to extension.

Conclusion: It can be concluded that habitual position leads to segmental hypomobility of the thoracic spine which may affect pulmonary function among physical therapy students.

Key words: Thoracic mobility, Lung functions, university students.

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1.Introduction:

Many studies declared that sedentary habits and the very low contributions of leisure activities in university students have negative impacts on the physical performance of the student (1, 2, 3).

The routine of university students with its lack of motion activities, sitting 8 hours daily, contributes to the faulty posture. Also, Hansraj (4) Explored the impact of environmental factors, such as posture, one-sided loading, excessive static strain, lack of physical activity, and incorrect exercise, on overall quality of life (5).

Individuals with limited mobility often experience restricted movement in the thoracic spine, specifically in axial rotation and extension in the sagittal plane (6).

The range of spinal mobility has changed with different positions, with limited mobility in the loaded position (standing and sitting) compared to the unloaded position (prone) (7) In addition, the habitual position reduces thoracic mobility, especially extension and has a small and poor correlation with the magnitude of standing thoracic kyphosis (8). The prevalence of a habitual posture results in excessive strain on the same joint structures and muscle groups (9). The lack of information reaching the central nervous system is caused by faulty motion stereotypes and muscular imbalance, resulting in muscle passivity. The primary factors contributing to muscle imbalance are hypokinesis, persistent overloading beyond the muscle's capacity, asymmetrical loading without adequate compensation, and alterations in mobility patterns (10)

The thoracic range of motion plays a significant role in respiration dynamics. This is because the thoracic spine is connected to all the ribs and has muscle attachments to a portion of the diaphragm, indicating its crucial involvement in respiratory mechanics (11). The average change in the T1-T12 physiological kyphosis angle from inhalation to exhalation was 15.9° ± 4.6°, indicating the degree of flexibility in the thoracic spine throughout deep breathing (30.2%). The caudal hemicircurve has a broader range of motion than the cranial hemicircurve, suggesting that the caudal part of the thoracic kyphosis is more flexible. From inspiration to expiration, there was a large range of motion at T7-T10. This motion accounted for 73% of the sagittal movement from T1-T12 (12) Mobility of the chest wall and spine is of interest from a biomechanical point of view since chest expansion requires functioning joint mobility, but also functioning muscles to create movement of the chest wall (13). Skeletal anomalies can affect respiratory function even when no pulmonary illness is present (14). In relation to respiratory function, research demonstrated that elderly individuals with limited movement in the chest have difficulty in breathing and malfunction in their ability to ventilate (15)

The spinal anomaly and its impact on lung function have garnered a lot of interest. But lung function evaluations are under-emphasized, even though these areas may be compromised by biomechanical alterations in the thoracic and spinal cord (16).

To our knowledge, the effect of prolonged faulty posture on lung function in this range of age was not studied clearly in the previous studies.

So, this study was designed to evaluate the relationship among spinal curvature status in university students and the pulmonary function of these students.

2.Patients and Methods

2.1. Study participants and recruitment criteria:

Forty-six undergraduate male students at the faculty of physical therapy at Deraya University participated in this investigation, the students were recruited either by direct contact or announcement on the signboard. The participants' mean age was 20.70 ± 1.87 years, the maximum age was 24 years, the minimum age was 19 years, the mean height was 173.35 ± 5.29, the mean body weight was 74.91 ± 11.82 kg, as well as the mean body mass index (BMI), was 24.87 ± 3.43 kg/m².

2.1.1 Ethical considerations

Before the initiation this study was approved by the Ethics Committee No: P.T. REC/012/004812. Faculty of Physical Therapy, Cairo University, Egypt. Before the subjects participated in our study, they gave their written consent. The inclusion criteria: age range 18- 25, BMI (18.5- 29.9), did not practice sports regularly for the last year, consent that staying in prolonged posture for at least 4 hours in the previous 3 months. The exclusion criteria were as follows. Individuals who took part in this study did not have a preexisting condition of scoliosis or spinal injuries (e.g., deterioration of the intervertebral joints, bulging or herniated discs, and narrowing of the spinal canal); had other internal organ or musculoskeletal disorders; and as well as any previous lung complaints or were smokers (17). Written informed consent was obtained from all participants after they were thoroughly briefed about the study's aim, nature, and procedures.

2.2. Study Design:

Between October 2023 and January 2024, one group cross section study was carried out to figure out the correlation between sagittal spinal variability in the thoracic region and lung function among physical therapy students. The data collection was conducted in the faculty of physical therapy, Deraya University. Measurements were performed by an examiner who was an experienced user of the spinal mouse device and another user of the spirometer device.

2.3. Methods:

2.3. Instrumentations

I- Medical scale.

Height and weight were assessed using a medical scale, and BMI was determined based on these measurements.

II- Spinal Mouse

While standing, subjects underwent noninvasive skin-surface measurements for computer-assisted imaging and radiation-free examination, as well as intersegment mobility, total and regional spinal ROM, and posture using a wireless electronic device called a Spinal Mouse (Idiag, Volker swill, Switzerland) the validity and reliability of the spinal mouse as a safe, reliable, and easy to use were established for research and follow-up (**Figure 1**) (18, 19,20). Through Bluetooth, the device transmits data to the computer, which then displays the curvatures that have been measured. Patients are not put at risk by this procedure. A pair of wheels move in tandem with the spine's natural curvature to record angles and distances, which are then transmitted to a computer for analysis (20).

Fig (1): Spinal mouse

III- Spirometer:

A valid and reliable spirometer used in this study was Geratherm Respiratory Blue Cherry version 1.2.2, which is a powerful central diagnostic software platform for all Geratherm Respiratory products in Germany (21). It is scalable from a small standalone spirometry system to a network-based, fully integrated pulmonary function laboratory, but it is easy to use because of its continuous operation. It makes evaluation and interpretation easy because it creates reports with exactly the right information. BLUE CHERRY® supports the measurement, review, interpretation and reporting of all measurements performed with geratherm respiratory devices: spirometry (SVC and FVC).

2.4. Procedure

2.4.1 spinal assessment

Spinal Mouse software was used to record each subject's sex, and age, and randomly assigned study codes before the start of the examination. The patient was undressed before palpating the spinous processes and marking C7 and S3 with a body marker. Vertebrae one through twelfth in the thoracic spine and vertebrae one through five in the lumbar spine were the areas measured. Prior palpation served as anatomical landmarks for the spinous processes of Th1, Th12, L1, and L5. One meter behind the subjects was where the Kinect sensor was positioned. The participants were instructed to stand in three distinct positions: relaxed but erect (not corrected), with the spine fully extended, and with the spine fully flexed. To capture the sagittal plane contour of the skin above the vertebral bodies, SpinalMouse was paravertebrally run along the spinous processes from C7 to S3 segments.

Standing Position:

1. Neutral in standing: The subject was instructed to remain in a comfortable posture, with their feet slightly wider than shoulder width apart, their knees straight, and their arms resting on their sides. They were also instructed to look straight ahead toward the wall.
2. Maximal flexion in standing: The patient was instructed to slowly move from one segment to the next while flexing their trunk with straight legs, with the goal of touching the ground with their fingertips.
3. Maximal extension while standing: Assuming a standing position with their knees straight and their arms crossed over their chest, the participant was instructed to extend their trunk as far as they could without bending their cervical spine.

We measured the spinal inclination and intersegmental angles about a ground-perpendicular vertical axis in each position. The examination data was used to determine the relative positions of the vertebrae. The software's "intelligent recursive algorithm" then evaluated the total and segmental ROM as well as the position of the spine, taking into account all 17 segments (Th1/Th2—L5/S1).

2.4.2 Lung Function Assessment

Lung function was assessed by a Geratherm Respiratory Blue Cherry spirometer, while the participant is in an upright position and wearing nose clips (22), catching a hand-held mouthpiece and being instructed to close his lips to avoid escaping air from the sides of the mouthpiece and ensuring a complete volume of air. Before starting the test, personal data, such as name, age, sex, weight, height as well as BMI, were obtained and recorded in the file. Then, the test started, and the participants were instructed to appear on the screen as tidal inspiration, deep inspiration, forced expiration, etc. The results of the test were collected and automatically recorded in a report by the Blue Cherry spirometer, and the examiner saved them on the device. During previous tests, three spirometry maneuvers were conducted. The forced vital capacity (FVC) as well as the forced expiratory volume in 1st second (FEV1) were analyzed from the maneuver with the highest FVC that met the criteria. The highest values of FVC and FEV1 from all acceptable maneuvers were used, following current guidelines (23).

3.Statistical Analysis:

Descriptive statistics were employed to display the demographic along with clinical information of the participants. The data's normality was assessed using the Shapiro-Wilk test. With the normally distributed data, the Pearson correlation coefficient was computed to examine the correlation among lung function as well as posture. The statistical tests were conducted with a predetermined level of significance of $p < 0.05$. The statistical analyses were conducted using the SPSS version 25 for Windows.

4. Results:

Subjects' characteristics:

Forty-six male individuals took part in this investigation. The participants' mean age was 20.70 ± 1.87 years, the maximum age was 24 years, the minimum age was 19 years, the mean height was 173.35 ± 5.29 cm, the mean body weight was 74.91 ± 11.82 kg, as well as the mean body mass index (BMI), was 24.87 ± 3.43 kg/m². Participant characteristics are presented in **Table (1).**

Pulmonary function and sagittal thoracic spinal mobility of the study group:

The mean ± SD FVC, FEV1, and FEV1/FVC of the study group were 78.83 ± 13.63, 77.57 ± 23.35 and 104 ± 19.09%, respectively.

The means ± SDs of posture from the fixed neutral position (stable position), posture from neutral to flexion, and posture from neutral to extension were 50.30 ± 8.41 degrees, -9.35 ± 11.74, and 1.22 ± 15.21, respectively **(Table 2).**

Table (1): Demographic data of patients**.**

	Mean ± SD	Maximum	Minimum
Age (years)	20.70 ± 1.87	24	19
Weight (kg)	74.91 ± 11.82	95	58
Height (cm)	173.35 ± 5.29	185	164
BMI (kg/m²)	24.87 ± 3.43	32.2	20.10
Condition, n (%)			
Normal	34	73.9	
Obstructive	2	4.3	]
Restrictive	8	17.4	
Mixed	2	4.3	

SD: Standard deviation.

Table 2. Descriptive statistics of pulmonary function and posture in the study groups:

		Mean ± SD	Mini	Max
Pulmonary function	**FVC (%) (liters)**	78.83 ± 13.63	43	103
	FEV1 (%)	77.57 ± 23.35	23	125
	FEV1/FVC (%)	104 ± 19.09	52	128
Posture	**The posture from fixed neutral position**	50.30 ± 8.41	39	70
	Posture during movement			
	from neutral to flexion	15.21 ±1.22	-37	41
	from neutral to extension	11.74 ±9.3	-35	20

Correlations between pulmonary function and sagittal thoracic spinal mobility of the study group:

The correlation between FVC and posture was moderately negatively correlated with posture from the fixed neutral position ($r = -0.643$, $p = 0.001$) and was not significantly correlated with posture from neutral to flexion or neutral to extension.

The correlation between FEV1 and posture was moderately negatively correlated with posture from a fixed neutral position ($r = -0.570$, $p = 0.001$) and was not significantly associated with posture from neutral to extension or neutral to flexion.

The correlation between the FEV1/FVC and posture was moderately negatively correlated with posture during movement from neutral to flexion (r

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= -0.322, p = 0.029). Still, it was not significantly correlated with posture from neutral to neutral to extension (**Table 3**).

5. Discussion:

This research aimed to describe the correlation between sagittal postural assessments and lung function in physical therapy students. The study included 46 students with a mean age of 20.70 ± 1.87 years, mean weight of 74.91 ± 11.82 kg, and mean BMI of 24.87 ± 3.43 kg/m².

This study is designed to answer the following questions:

Is there any correlation between sagittal spinal mobility in the thoracic region and lung function among physical therapy students? Consequently, thoracic hypomobility could affect lung function, and how prolonged faulty posture can affect lung function in undergraduates as a population tends to the negative impact of prolonged position.

It was hypothesized that there would be no correlation between sagittal spinal variability in the thoracic region and lung function among physical therapy students.

The results showed a moderately negative correlation between FVC, FEV1, and posture from the fixed neutral position (r = -0.643, p = 0.001) and (r = -0.570, p = 0.001) respectively but was not significantly correlated with posture from neutral to flexion or neutral to extension. The correlation between the FEV1/FVC and posture was moderately negatively correlated with posture during movement from neutral to flexion (r = -0.322, p = 0.029) but not significantly associated with posture from neutral to neutral to extension.

The range of thoracic mobility in flexion and extension in habitual position was recorded to be lower than other measured positions either loaded position (sitting, standing) or unloaded (prone), as reported by Stephen et al 2011, indicating the effects of prolonged position on thoracic mobility (24, 25).

According to Katarzyna et al 2022, this decrease in thoracic mobility is strongly correlated with the mobility of the entire spine. They discovered significant correlations in the alignment of the sacrum to the lumbar spine (strong correlation), the alignment of the lumbar spine to the thoracic spine, as well as the alignment of the thoracic spine along with mobility in the direction of flexion in the thoracic segment (moderate correlation (26).

Gunnhild et al. (2012) found that patients with ankylosing spondylitis had a clear correlation between restricted pulmonary function and reduced spinal mobility compared to subjects with normal spinal mobility. The results highlight the need to preserve spinal flexibility in the treatment of Ankylosing Spondylosis and confirm the hypothesis of a link between musculoskeletal restrictions and restrictive respiratory impairment (27, 28)

The results of these studies agreed with the reports mentioned above which indicate that prolonged habitual positions affect thoracic spine mobility which in turn impacts the lung function.

The statistical findings corroborate those of a 2017 study by Gonçalves et al., who found that COPD patients and healthy people have different postural alignments of the anterior tilt of the right and left pelvis as well as thoracic kyphosis. Pneumonia and postural alignment are related in COPD patients (29).

In a systematic review of 43 papers examining the impact of body position on pulmonary function, Katz et al. (2018) found that pulmonary function was enhanced when individuals maintained a more upright posture. This improvement was observed in both healthy individuals and those with conditions such as lung disease, heart disease, neuromuscular diseases, as well as obesity (30,31).

A significant and favorable correlation among the upper chest's APM as well as pulmonary function was reported and in tandem with the results of the current research. Furthermore, there was a notable prevalence of kyphoscoliosis, and the alignment of the head in a horizontal position (HHA) exhibited a significant inverse relationship with pulmonary function (32).

Table 3. Correlation between pulmonary function and posture:

	Pulmonary function					
	FVC (%)		FEV1 (%)		FEV1/FVC (%)	
	r – value	p- value	r - value	p- value	r - value	p- value
Posture from fixed neutral position	-0.6	0.001	-0.6	0.001	-0.1	0.41
Posture during movement from neutral to flexion	-0.1	0.43	-0.2	0.20	-0.3	0.02
Posture during movement from neutral to extension	0.09	0.52	0.11	0.45	0.03	0.8

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Burgos et al 2021 in a cross-sectional study on 40 patients, reported differences between the inspiration and exhalation of about 15 degrees in the T1-12 physiologic kyphosis reflecting the role of thoracic flexibility during breathing, indicating that thoracic spine mobility has a positive correlation in respiration dynamics (12).

The connection between the spine with all ribs and muscles attached to it was studied by Masuda et al, their findings indicated that the spine, which serves as the ribcage's pivot, was nearly stationary during tidal breathing. Breathing to Respiratory Volume or Total Lung Capacity activated a variety of supplementary respiratory muscles and altered the spine (27).

Finally, the pulmonary function in elderly patients with impaired lung functions was significantly improved ($p<.05$). For the FEV1, FVC, and FEV1/FVC. After a course of thoracic spine mobilization, that reflects the impact of thoracic hypomobility on pulmonary function (33).

The study reports the effect of prolonged faulty posture on pulmonary function at a young age which is considered a strength of the study. In addition, correlating the spinal hypo-mobility on lung function in normal subjects is a scope of interest.

On the other hand, the study needs a larger sample size, and to be on male and female.

Conclusion:

In light of the results of this study, it was determined there is a significant correlation between posture in the neutral position and FVC and FEV1 While no significant correlation with FEV1/FVC, during movement of the thoracic region in the sagittal plane there is a significant correlation between posture as well as FEV1/FVC while there is no significant correlation between posture and FEV1, and FVC. That means habitual position leads to segmental hypomobility of the thoracic spine, which may affect pulmonary function among physical therapy students.

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