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Correlation between Aberrant Upper Body Posture and Shoulder Function in Subacromial Impingement Syndrome

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ABSTRACT
Background: The most frequent condition affecting the shoulder is likely subacromial impingement syndrome (SIS). Although there is evidence linking upper body posture and shoulder function, there is no evidence linking posture to SIS.

Objective: To determine the relation between aberrant upper body posture and shoulder ROM. Also, to determine the relation between aberrant upper body posture and shoulder disability levels in cases of SIS.

Patients and Methods: The study included 37 subjects with SIS (group B), their mean age was 28 years, (male & female) and 37 age and gender-matched controls (group A). Upper body posture was analysed using bubble inclinometer for thoracic kyphosis (TK) measurement, lateral scapular slide test (LSST) for detecting scapular dyskinesia (SD), tape for pectoralis minor length measurement.

Results: There was statistically significant reduction in mean values of kyphosis in favor to control group (P=0.027). But there was statistically significant increase in mean values of pectoralis minor length in favor of control group (P=0.033). Also, no statistically significant differences in mean values of LSST at the three different positions were found between both groups (P > 0.05). Within the SIS group there was no statistical significant correlation between aberrant upper body posture (thoracic kyphosis, scapular dyskinesia and pectoralis minor length) and passive shoulder flexion ROM, passive shoulder abduction ROM, shoulder pain and disability levels.

Conclusion: Patients with SIS had a more exaggerated TK and less pectoralis minor length and no difference in scapular position compared to age- and sex-matched normal controls.

Keywords: Aberrant upper body posture, Kyphosis, pectoralis minor, Scapular dyskinesia, Subacromial impingement syndrome.

INTRODUCTION

Pathologies in the subacromial area, which is located above the glenohumeral joint, can cause Subacromial Impingement Syndrome (SIS), which is a painful disorder. Another name for it is outlet impingement syndrome [1]**.** More than half of complaints of shoulder discomfort are due to SIS, which is the most frequent cause**.** A significant amount of functional impairment results from the gradual pain that SIS patients experience during overhead motions and arm elevation within the uncomfortable arc (70–120 abduction degrees) [2]. The subacromial bursa inflammation, rotator cuff tendon degeneration, weak rotator cuff and scapular musculature (muscle imbalance), abnormal activation patterns of muscles of the shoulder girdle, and postural dysfunction of scapula and spinal column are just a few of the extrinsic and intrinsic factors that can cause symptoms of SIS [3]**.**

One anatomical region that may have an impact on how the shoulder functions is the thoracic spine. Numerous writers have looked into potential connections between SIS and upper body posture [4]**.** The presence of a thoracic kyphotic posture, which is connected to an anteriorly tilted, downward rotated, and prolonged scapular posture and denotes a reduction in glenohumeral joint elevation in these individuals with SIS, is a sign of SIS [5].

Slouching may affect scapular kinematics and reduce subacromial space due to the greater thoracic curvature it causes [6]**.** Additionally, they might negatively influence the length-tension relationships of shoulder girdle muscles, resulting in improper tracking of the humerus head inside the glenoid fossa [7]**.** In order to guarantee that the dynamic subacromial space is maximised and restore normal movement patterns, postural correction may be necessary [6]**.** In those with normal upper body posture, the scapula offers a secure basis for the rotator cuff and other muscles which cross the glenohumeral joint to work well [7]**.** It is a vital link in the kinetic chain that enables the proper transmission of power from the body's centre to the arm [8]**.** An alteration of static posture and abnormal scapular mobility are the characteristics of scapular dyskinesia. Given that it can exist in people who have no symptoms, it is best understood as a limitation of ideal shoulder function [9]**.**

There are musculoskeletal causes, including the tightness of pectoralis minor and biceps, posterior shoulder inflexibility, lesions of peri-scapular muscles, changes in muscular activation, strength imbalance, clavicle fractures, and unstable acromioclavicular and glenohumeral joints. Incorrect postures like TK might all be connected to SD [10]**.** Scapular dyskinesia has been linked to multidirectional deficits, rotator cuff tendinopathy, and shoulder discomfort, more especially SIS [9]. The reduced sub-acromial space, which may lead to the most common shoulder diseases, including SIS, is a result of the altered scapular mobility. Additionally,

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it weakens the RC and puts more strain on the anterior glenohumeral ligaments [(10)].

Researchers have hypothesised that in people with SIS, the pectoralis minor may disrupt normal scapular kinematics through increased active or passive stress [(11)]. In healthy people, the active scapular upward rotation, external rotation, as well as posterior tilting which take place on arm elevation cause the pectoralis minor to passively lengthen [(12)].

The activation of the stabilising muscles, including the levator scapulae and upper trapezius, together with the mobilising muscles, like the pectoralis minor, might be affected by abnormal scapular orientations. Continuous forward shoulder position (FSP) leads the pectoralis minor and other anterior muscles to adaptively shorten and tighten, which increases the anterior tilt as well as the internal/downward rotation of the scapula. Such FSP-related scapular patterns can compress the subacromial soft tissues, depress the acromion, and limit sub-acromial space clearing, resulting in painful shoulder elevation, mobility restriction, weakness, and functional impairment [(13)].

PATIENTS AND METHODS

The assessment procedures were performed at outpatient clinic at Faculty of Physical Therapy, Cairo University Egypt. The time taken to complete the practical part of this study was from September 2022 to March 2023.

I- Study Participants and recruitment criteria:
Seventy-four individuals aged 18 - 40 years of both sexes were divided into 2 groups (each = 37). Group (A) included individuals without history of upper limb painful ailments or surgical procedures while group (B) included those with unilateral shoulder pain for > one week localized to the acromion. Group B was enrolled from the Out-patient Clinic of Faculty of Physical Therapy, Cairo University.

The inclusion criteria of asymptomatic subjects: Patients of both sexes aged 18- 40 years who have never had surgery or a painful ailment affecting their upper limbs.

The inclusion criteria for patients with SIS: Participants who were both sexes and ranged in age from 18 to 40. Localised anterior and/or lateral to the acromion, unilateral shoulder ache lasting more than a week [(13)]. Pain that is caused by or worsens when the afflicted shoulder is in flexion and/or abduction [(13)].

The included patients had four of the following: The Neer impingement indication is positive. A positive Hawkins sign. The supraspinatus empty-can test recreated pain. An arc of movement between 60° and 120° that is painful. Painful greater tuberosity of humerus that is palpable [(13)].

The exclusion criteria for the 2 groups included: Systemic conditions - Pregnancy - Cervical discomfort while moving the neck or while at rest. Development of shoulder symptoms during cervical motions (flexion, extension, left rotation, right rotation, left side flexion, right side flexion). Development of shoulder symptoms after adding overpressure at the end of left and right cervical rotation, left rotation in combination with left side flexion, and right rotation in combination with right side flexion. Previous surgeries on the spine or higher limbs. Previous fractures of the spine or upper limbs. Post-traumatic start of symptoms [(13)].

II- Instrumentation:

1. The bubble inclinometer: The gravity-dependent inclinometer is made by baseline Inc. in White Plains, New York, and has two feet that extend from the base as well as a Perspex protractor with a freely swinging pointer. According to **Lewis *et al.*** [(13)], this pointer measures the angle tangent to the surface being measured.

It has criterion validity and can measure thoracic kyphosis. It was used to evaluate thoracic kyphosis. A strong linear correlation was found between modified Cobb angle and the inclinometer values for thoracic (correlation coefficient =0.62) [(14)].

2. Pectoralis minor length index (PMI): It is computed by dividing the resting pectoralis minor length (in centimetres) by the participant's height (in centimetres), then multiplying the result by 100 to get the relative pectoralis minor length. When 7.65 or below, PMI is said to represent a short pectoralis minor [(15)].

An earlier report for individuals with and with no shoulder pain established the intrarater reliability (intraclass correlation coefficient [ICC] 14 0.95-0.97; standard error of measurement [SEM] 14 0.31-0.42 cm), interrater reliability (ICC 14 0.86-0.87; SEM 14 0.70-0.84 cm), and between-days reliability (ICC 14 0.95; SEM 14 0.40-0.41 cm) of this measurement [(16)].

3. The Lateral Scapular Slide Test (LSST): The distance from the inferior scapular angle and the neighbouring thoracic spinous process is used to calculate LSST (4). For this testing technique, three locations are chosen. 1. Side arms relaxed. 2. Hands on hips with approximately 10° of shoulder extension 3. Arms abducted to about 90° with maximum internal rotation of glenohumeral joint. [(17)]. A difference of 1.5 cm should be used to determine whether scapular asymmetry exists [(18)]. It is a trustworthy objective assessment of scapular position (ICC varied from 0.7 to 0.96) [(4)].

4. Smart Phone: A gyro-sensor system that allows for numerous inclinometric functionalities has been added to smart phones. When measuring range of motion (ROM) of the shoulder on a smart phone, the intra-observer reliability was outstanding with an ICC value > 0.9 [(19)].

5. Shoulder Pain and Disability Index (SPADI): The SPADI, which has 5 pain categories and 8 categories of impairment, is used to measure shoulder discomfort and disability. There is a visual analogue scale for each category that ranges from 0 to 10. A subject who receives a score of 0 in the pain category feels no pain, whereas a subject who receives a score of 10 is in excruciating pain. Similarly, a disability category score of 0 implies no difficulty, while a score of 10 points to excruciating suffering. Therefore, a higher score denotes more pain or impairment intensity [20].

Due to the Arabic SPADI's strong correlates with Quick DASH, NRS, and shoulder ROM, it demonstrated great internal consistency and test-retest reliability (ICC 0.95 [0.91-0.97]) as well as construct validity. To assess those with shoulder dysfunction, SPADI is advised [21].

III- Assessment procedures:

In addition to quantifying shoulder discomfort and impairment for the study group alone, measurements for both groups included thoracic kyphosis, thoracic flexion and extension ROM, scapular dyskinesia, PM length, and shoulder ROM.

1. Thoracic kyphosis assessment: With the exception of ladies wearing gowns that were open in the back, patients were requested to take off their upper body clothes. On the skin above C7 and T12 spinous processes, two pencil scribbles were made. Each participant was advised to sit at ease and to stare straight ahead at the wall in front of him while seated on a bench with their feet level on the ground. Prior to measuring this neutral sitting posture, the inclinometer was zeroed on a vertical wall. The cephalic foot of this inclinometer was positioned on the pencil mark on the C7 process in accordance with conventional clinical practice. The lower thoracic spine was next subjected to the same process, with the inclinometer's caudal foot being positioned on the pencil mark established for T12. By placing eye level on the same horizontal plane of the inclinometer and recording both inclinometer angles, parallax error was minimised with each measurement (figure 1). And the difference between the two inclinometer readings was used to calculate the TK value [22].

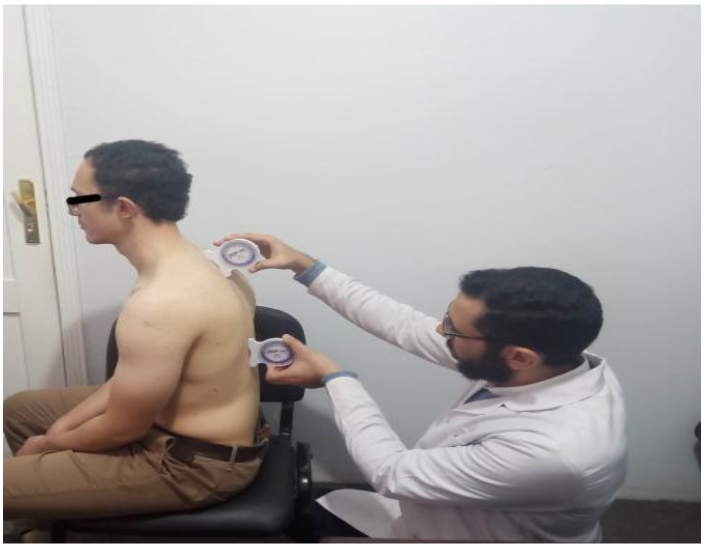

Figure (1): Arrangements of the cephalad and caudal inclinometers for measuring thoracic kyphosis.

2. Pectoralis Minor length assessment:

Using a tape with 0.10-cm precision, PM length was measured, while the subject was at rest. According to **Borstad and Ludewig [15],** the inferomedial side of coracoid process and the caudal border of the 4th rib at the sternum underwent palpation, marked using a pencil, and utilized to represent PM length. With a two-minute gap between each measurement, this distance was measured 2 times. Participants were instructed not to alter their posture during the resting position measures, to maintain a comfortable stance with the arms at sides in a neutral position, and to exhale right pre-measurement. After each measurement, the pencil traces were erased (figure 2). The relative pectoralis minor length (PML), which is thought to signify a shortened pectoralis minor when 7.65 or below, was computed by dividing the person 's height (cm) by his/her resting length (cm), and multiplied by 100 [15].

Figure (2): Pectoralis minor measurement of length.

3. Scapular dyskinesia:

The distance from the inferior scapular angle to the nearby thoracic spinous process was measured with a tape. Participants were instructed to stand with their arms at sides as a tape was utilized to measure the initial position of the lateral sliding test in cm on both sides. After demonstrating the second posture, the examiner instructed the subject to put their hands on their hips and used the same tape measure to measure the distance in millimetres on either side. The participant watched the examiner perform the third position, and measurements were once more obtained utilizing the same tape (figure 3). Each participant's side was randomly assigned before being measured [17].

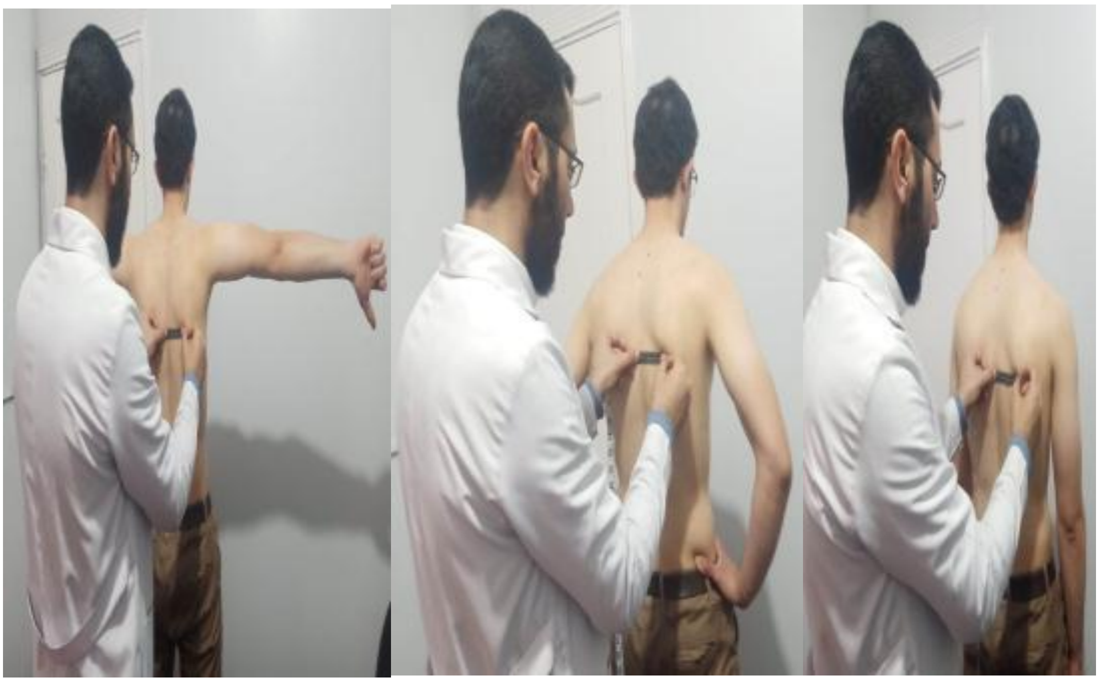

Figure (3): Measurements of LSST. A) Arm at the side standing in dependent position; (B) Arm abduction with hand resting at hip; (C) Arm abduction of 90 degrees with internally rotated shoulder.

4. Shoulder ROM assessment:

A Dual Fit Armband was used to secure the smartphone to the ventral side of forearm at the wrist level. To measure the ROM in flexion and abduction, patient was asked to stand with both the back and buttocks contacting the wall. The patient's arm was elevated in sagittal plane to measure the passive flexion and in coronal plane to assess the passive abduction while maintaining straight elbows. After setting the vertical line to zero, the observer read the data for the inclinometric measurement. To prevent body bending to contralateral side during flexion and abduction movement, both arms were raised at the same time (figure 4) [19].

Figure (4): Smartphone inclinometer measurement of the shoulder flexion ROM

5. Shoulder pain and disability levels:

The SPADI, which has five categories for pain and eight for disability, was used to evaluate shoulder discomfort and impairment. A visual analogue scale (0-10 points range) is available for each category. A subject who receives score 0 in the pain category feels no pain, whereas a subject who receives a score of 10 is in excruciating pain. Similarly, a disability category score of 0 implies no difficulty, whereas a score of 10 indicates excruciating suffering. Participants were instructed to score the level of symptomatology using a scale. The total score was calculated as the sum of all 13 categories [20].

Ethical approval: Our study obtained approval from Ethical Committee of Faculty of Physical Therapy, Cairo University. After being fully informed, all participants provided written consents. It was conducted in line with the Helsinki Declaration.

Statistical analysis

Data were analyzed by SPSS (Statistical Package for Social Sciences) v 24 for Windows® (IBM SPSS Inc., Chicago, IL, US). Normality of distribution of data was tested by the Shapiro Walk test. Qualitative data were expressed as numbers and percent. Chi square test (χ^2) calculated difference between ≥ 2 groups of qualitative variables. Quantitative data were described as means ± SDs (Standard deviations). Independent samples t-test was utilized for comparison between 2 independent groups of normally distributed variables (parametric data). Significance of a result was judged at P value ≤ 0.05.

RESULTS

Seventy four subjects participated in our study. Subjects were assigned into 2 equal groups, group (A) included subjects who had no history of upper limb painful conditions or surgeries and group (B) included patients with SIS. As shown in table (1), mean values of age of group A and group B were 26.3 ± 3.5 and 28 ± 4.7 years respectively. The mean values of weight of group A and group B were 76 ± 8 and 77.6 ± 10 kg respectively, the mean values of height of group A and group B were 174.9 ± 6.3 and 174.7.2 ± 8.3 cm respectively. The mean values of BMI of group A and group B were 24.8 ± 2.1 and 25.3 ± 2.1 kg/m^2 respectively. No significant differences existed among both groups regarding mean age, weight, height and BMI. The number (%) of males of groups A and B were 33 (89%) and 28 (75.7%) and the number (%) of females 4 (11%) and 9 (24.3%) respectively. No significant difference existed as regards gender distribution, between the groups (p =0.221).

Table (1): Subjects characteristics of study groups

Measurd variable	Group A	Group B	t-value	p-value
Age (years)	26.3±3.5	28±4.7	-1.8	0.072
Weight (kg)	76±8	77.6±10	-0.769	0.445
Height (cm)	174.9±6.3	174.7.2 ± 8.3	0.126	0.900
BMI (kg/m^2)	24.8±2.1	25.3± 2.1	-1.09	0.227
Sex distribution Males Females	Number (%) 33 (89%) 4 (11%)	Number (%) 28 (75.7%) 9 (24.3 %)	Chi square 0.127	0.221

Data are represented as Means ± SD.

Comparisons of thoracic kyphosis, scapular posture, and pectoralis minor length between the SIS and asymptomatic control groups, are listed in table (2) and figures (5-8). A statistically significant reduction in mean values of kyphosis was reported in favour of group A (P=0.027). The mean of kyphosis for subjects in two groups (A and B) were 34.3 ± 6.9 and 39.7 ± 12.8 degrees respectively. A statistically significant increase in mean values of pectoralis minor length was reported in favour of group A (P=0.033). The mean of pectoralis minor length for subjects in the two groups (A and B) were 8 ± 0.57 and 7.7 ± 0.58 cm respectively.

There were statistical significant increase in mean values of passive shoulder flexion in favor of group A (P=0.046). The mean of passive shoulder flexion in two groups (A and B) were 178 ± 2.7 and 175 ± 7.7 degrees respectively. There were statistical significant increase in mean values of passive shoulder abduction in favor of group A (P=0.003). The mean of passive shoulder abduction in two groups (A and B) were 176 ± 5 and 166 ± 20.3 degrees respectively.

No statistically significant differences in mean values of LSST at the three different positions existed between both groups (P>0.05). The mean (95% CI) of LSST in neutral position for subjects in two groups (A and B) were 0.054 (-0.24, 0.35) and 0.23 (-0.06, 0.52) respectively, the mean (95% CI) of LSST at 45 shoulder abduction for subjects in two groups (A and B) were 0.068 (-0.36,0.22) and 0.32 (0.035, 0.61) respectively and the mean (95% CI) of LSST at 90 shoulder abduction for subjects in two groups (A and B) were -0.108 (-0.39,0.18) and 0.189 (-0.1, 0.48) respectively.

Table (2): Comparison of the measured variables between groups

Measured variables	Group A	Group B	Mean difference	P - value
Thoracic	34.3 ± 6.9	39.7 ±	-5.4	0.027*
Pectoralis	8 ± 0.57	7.7 ±	0.29	0.033*
Passive	178 ± 2.7	175 ±	2.8	0.039*
Passive shoulder abduction (degree)	176 ± 5	166 ± 20.3	10	0.005*

Data are represented as Means ± SDs

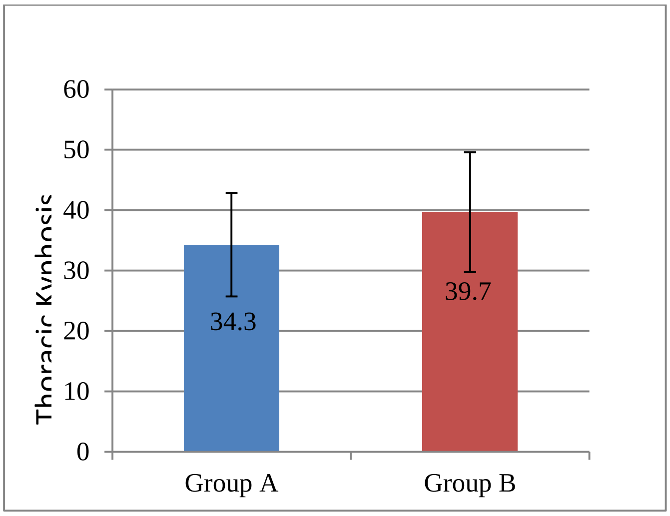

Figure (5): Mean values of thoracic kyphosis of the study groups.

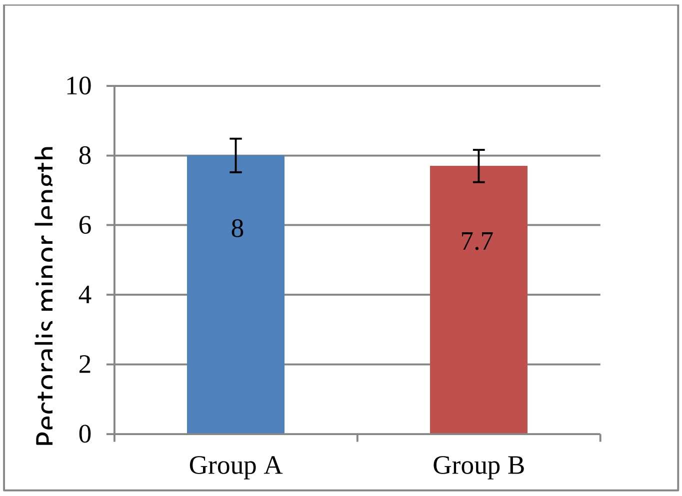

Figure (6): Mean values of pectoralis minor length of the study groups

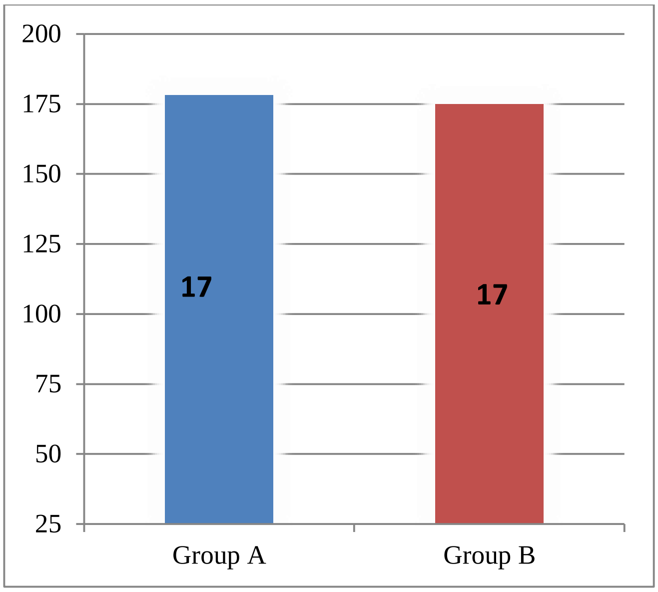

Figure (7): Mean values of shoulder flexion of the study groups.

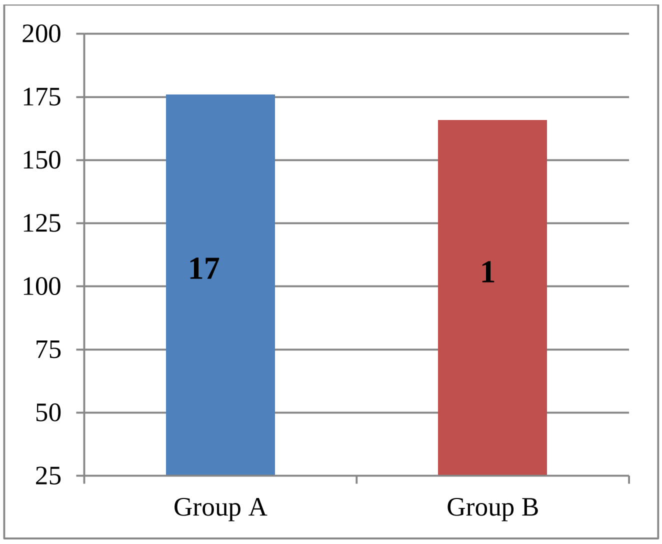

Figure (8): Mean values of shoulder abduction of the study groups.

As shown in table (3), there was significant indirect weak correlation between kyphosis and passive shoulder abduction (r=-0.357) (p=0.030). Also, between SPADI and pectoralis minor length, LSST at neutral, at 45 and at 90 abduction (r= -0.334, -0.432, -0.438 and -0.349) (p=0.044, 0.008, 0.007 and 0.034) respectively.

Table (3): Pearson Correlation between kyphosis, thoracic ROM, LSST, shoulder ROM and SPADI.

Variables		Passive shoulder flexion	Passive shoulder abduction	SPADI
Khyphosis	r value	-0.188	-0.357	0.078
	p value	0.265	0.030*	0.647
Thoracic flexion	r value	-0.203	-0.222	-0.022
	p value	0.228	0.187	0.897
Thoracic extension	r value	-0.156	-0.140	-0.044
	p value	0.358	0.410	0.794
Pectoralis minor	r value	-0.035	-0.028	-0.334
	p value	0.838	0.871	0.044*
LSST neutral	r value	0.121	-0.016	-0.432
	p value	0.476	0.927	0.008*
LSST 45	r value	0.231	-0.011	-0.438
	p value	0.170	0.946	0.007*
LSST 90	r value	0.077	-0.071	-0.349
	p value	0.650	0.676	0.034*
Passive shoulder flexion	r value		0.289	-0.200
	p value		0.082	0.235
Passive shoulder abduction	r value			-0.293
	p value			0.078

DISCUSSION

Clinicians frequently depend on the theory that an abnormal posture of the upper body may cause the supraspinatus tendon to impinge on the front part of the acromion process. This has been incorporated into therapeutic practices to educate individuals on the connection between bad posture and the onset of SIS, to support postural exams, and to justify treatment plans. Unfortunately, studies looking at SIS postural changes have had contradictory results [(4)].

According to the current study's findings, persons with SIS had considerably more TK than asymptomatic subjects who were matched for age, gender, and dominant arm. On average, these participants had a greater thoracic kyphosis of 5.4°. Clinicians may take this into account when managing patients with SIS since TK may be physically changeable with exercises or manual treatment. This conclusion was validated by research of **Hunter *et al.*** [(20)]**,** who discovered that patients with SIS had a statistically significant mean increase in thoracic kyphosis when compared to the healthy controls (using lateral thoracic spine radiograph for measuring the modified Cobb angle).

A substantial relationship between SIS and individuals with higher TK was also discovered by **Otoshi *et al.*** [(23)] in 2144 people above the age of 40. The wall-occiput test was utilised in this study for comparison of the TK among participants. If a participant cannot place his/her occiput against the wall when the back and heels are in touch with it, the test is said to be affirmative; nevertheless, there was no computation of an actual angle of TK. On the other hand, **Greenfield and co-workers** [(24)] did not find correlation between thoracic position and shoulder discomfort after analysing radiographs and comparing the posture of people with shoulder overuse injuries with unaffected persons.

Theisen *et al.* [(25)] did not discover a connection between SIS and static sitting thoracic kyphosis using ultrasonic topometry.

Lewis and Valentine [(26)] also found no changes in TK between groups with and with no shoulder discomfort on standing and at rest. And other earlier research [(4, 26, 27)] examined participant samples from people in their teens, twenties, and thirty some things and did not discover a connection between thoracic kyphosis and SIS. The results of **Lewis and colleagues** [(5)]**,** who did not report correlation between TK and shoulder range of motion in the direction of flexion and abduction, supported our study's finding that there was no correlation between TK and passive shoulder flexion and abduction within the SIS group. These findings contrast with the review by **Barrett *et al.*** [(28)]**,** which found significant evidence that increasing TK through slouched sitting decreases maximum shoulder.

According to the results of the review, there is either a mild or no link between increasing thoracic kyphosis and shoulder discomfort [(28)]. In the current investigation, no significant correlation was found between kyphosis angle and shoulder pain and disability within the SIS group. According to the study's findings, a non-significant difference was found regarding the mean LSST scores at any of the three positions between the two groups. Additionally, there was no correlation between scapular dyskinesia and shoulder range of motion, pain, or disability levels. The reliability and specificity of the first reported approach have been questioned by recent LSST research [(19)].

This conclusion was reinforced by **Lukasiewicz *et al.*** [(29)], who reported a non-significant difference between asymptomatic patients and those with SIS in the medial-lateral scapular position. The scapula's protraction, rotation, and symmetry between the patient group and normal group, as well as between the affected and unaffected sides within the patient group, did not significantly differ, according to **Greenfield *et al.*** [(24)]. These findings somewhat conflict with that of **Kibler** [(18)]**,** who discovered a 1 cm larger difference between the affected and uninvolved sides of the scapula in individuals with shoulder injuries. According to **Alizadehkhaiyat *et al.*** [(4)]**,** abducting the afflicted arm to 90º (LSST3) caused the only significant change in LSST to be seen among female subjects.

Radiographs were employed in a different investigation by **Endo *et al.*** [(30)]**,** which evaluated 27 participants with chronic SIS for upward rotation, superior-inferior position, and protraction of the scapula. Additionally, they discovered kinematic variations in the SIS individuals. However, the scapula's resting position was the same in the afflicted and unaffected shoulders. It is unclear whether these alterations contributed to or were a result of the underlying disease in the investigations that have shown variations in scapular position between asymptomatic and symptomatic participants [31, 32].

According to the study's findings, the mean pectoralis minor length was significantly lower among SIS patients in comparison with controls, but no correlation was found between PML and pain or disability levels, nor was there any correlation between PML and shoulder ROM. No significant correlation between PML and pain-function as assessed by SPADI was discovered by **Navarro *et al.*** [33]. According to **Borstad and Ludewig** [15], patients with shorter pectoralis minor displayed scapular kinematic patterns comparable to patients reported in shoulder impingement, such as considerably reduced scapula's posterior tilt and greater scapular internal rotation during arm elevation.

CONCLUSION

According to the study's findings, there is a link between SIS and abnormal upper body posture. People with SIS showed more TK and less pectoralis minor length compared to matched asymptomatic people. To evaluate if TK is the cause or result of SIS, longitudinal investigations are necessary. These findings imply that besides the treatment of the shoulder joint, TK and pectoralis minor stretch should be addressed in SIS therapy procedures.

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