

ORIGINAL RESEARCH ARTICLE

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# The effect of scapular dyskinesia on the scapular balance angle and upper extremity sensorimotor function in stroke patients with spasticity

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## Abstract

**Background:** Post-stroke scapular dyskinesia is a predisposing factor for the affection of motor and somatosensory functions of the hemiparetic upper extremity.

**Objective:** The purpose of the study was to investigate the effect of scapular dyskinesia on the scapular balance angle and upper extremity sensorimotor function in stroke patients with spasticity.

**Subjects and methods:** Sixty patients with spasticity post-stroke participated in this study. The patients were assigned to one of the two groups as determined by the lateral scapular slide test (LSST) using the palpation meter (PALM); group A with scapular dyskinesia and group B stroke patients without scapular dyskinesia. The scapular position was determined by a measurement of scapular balance angle (SBA), and the upper extremity sensorimotor function was evaluated using Fugl-Meyer Assessment upper extremity (FMAUE) scale. The scapular balance angle and Fugl-Meyer upper extremity scores were compared between groups.

**Results:** There was a significant increase in the scapular balance angle of group A compared with that of group B ( $p < 0.001$ ). Also, there was a significant decrease in sensory and motor functions of group A as measured by Fugl-Meyer upper extremity compared with that of group B ( $p < 0.001$ ).

**Conclusion:** Scapular dyskinesia had a significant effect on the scapular balance angle and upper extremity sensorimotor function in stroke patients with spasticity. Management of scapular dyskinesia should be emphasized in the rehabilitation program for stroke patients with spasticity.

**Keywords:** Scapular dyskinesia, Scapular balance angle, Sensorimotor function, Stroke

## Background

Upper limb incapacity considered a significant issue in stroke patients [1]. Following a stroke, there is a low-tone flaccid stage while there is no voluntary control,

trailed by spastic stage. The spastic and flaccid stages cause serious brokenness in the shoulder joint and likewise scapulothoracic joint asymmetry (dyskinesia) [2]. In the first flabby flaccid stage, there are great changes of the glenoid fossa angle because of the hypotonia of the trapezius, serratus anterior, and rhomboid muscles that reason scapular descending revolution, depression, and protraction, which may prompts, hence adding to subluxation [3]; while during the spastic stage, the tone of the flexor is the predominant in the upper extremity

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(UE), causing scapular withdrawal in retraction and depression with adduction at the shoulder [4, 5].

Changes in the position and movement of the scapula refer to the term scapular dyskinesia [6]. “Dys” alluded to “alternation of” while “kinesis” alludes to “movement” that demonstrates the loss of ordinary control of scapular movement. There are many neurological component especially joint sense and motor functions which affect developments of scapular dyskinesia [7]. In scapular dyskinesia, there might be dysrhythmia (hyper or hypo movement during elevation and bringing down of scapula) or winging (noticeable quality of any part of the medial edge or inferior angle away from the thorax) [8].

Kibler et al. [6] arranged scapular asymmetry (dyskinesia) as follows: the first type presents inferior dysfunction, because the scapular front tilting and the inferior angle are prominent, while the second type gives the medial dyskinesia with the medial border of scapula more prominent as the consequence of scapular inner pivot and the third type is the superior dysfunction with the expanded rise of the scapula during upper limb elevation. In the lateral scapular slide test, the first and second types are more evident in the position of hands-on-hips.

Shoulder dysfunction and pain in stroke is caused primarily by the irregular position of the scapulothoracic joints [9]. The draw of serratus anterior and lower trapezius guarantees a stable scapulothoracic joint that is important to diminish the hazard for subacromial impingement, most likely by giving satisfactory scapular horizontal turn and back tilting [10]. In a stroke, there is the debilitation of selective muscle performance [11]. Loss of motion or paralysis of any of these muscles brings about the winging of the medial scapula as it lifts off the thoracic divider. Also because of unopposed muscle withdrawal of the other working scapular muscles, the scapula may tilt medially or horizontally along the back thoracic divider [12].

As the upper extremity tasks happen with the consequence of the incorporated, multisegmented, successive joint movement, and muscle activation framework through the motor kinetic chain [13], scapular dyskinesia directly affects the upper limb performance.

Along these lines, the purpose of this study was to explore the impact of scapular dyskinesia on the scapula balance angle and the upper limb sensorimotor capacity in stroke persistent with spasticity. This study relies upon the appraisal of scapular balance angle (SBA) to survey the position and pivot of the scapula in clinical practice [14], and Fugl-Meyer Assessment (FMA) for estimating sensorimotor capacities for stroke patients, in light of Twitchell and Brunnstrom’s idea of consecutive phases of motor return in the hemiplegic stroke patient, that is created as the main quantitative evaluative instrument [15].

## Methods

The study aimed to investigate the effect of scapular dyskinesia on the scapular balance angle and upper extremity sensorimotor function in a stroke patient with spasticity.

## Design

An analytic cross-sectional study was directed to investigate the impact of scapular dyskinesia on the SBA and upper extremity sensorimotor function in stroke patients with spasticity. Each evaluation was performed by the same examiner for all patients.

## Participants

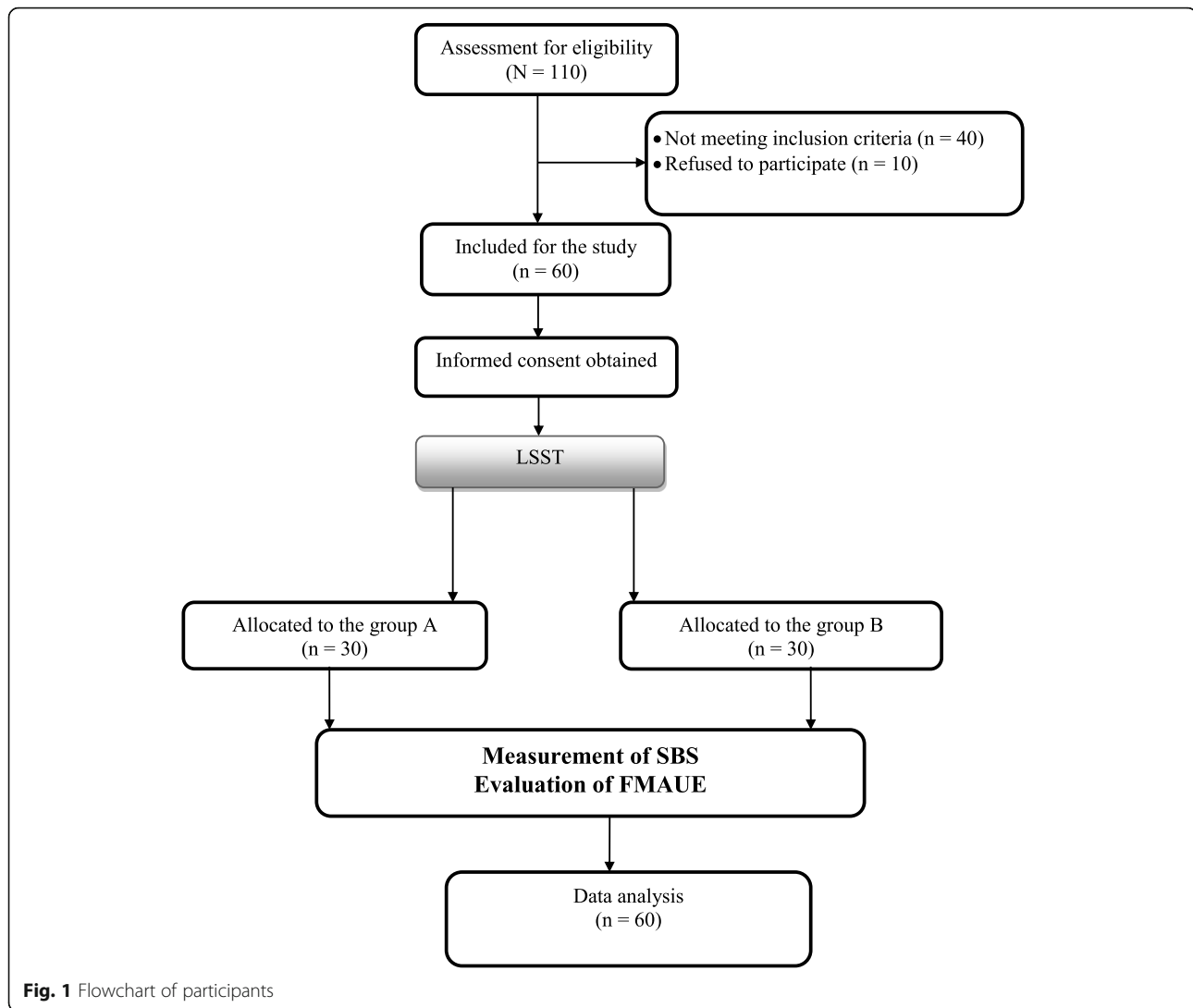
Sixty spastic stroke patients participated in this study. This study was conducted in the outpatient clinic of the Faculty of Physical Therapy, Neurological Department, Cairo University, and outpatient clinic of the Faculty of Physical Therapy, 6th October University Hospital. All the patients were classified by lateral scapular slide test (LSST) to group A with scapular dyskinesia and group B without scapular dyskinesia. All the patients were evaluated with a neurological examination. All the patients received verbal and written information about the study and gave written consent to participate, before the beginning of the study; Fig. 1 showed the flowchart of participants. The anonymity and confidentiality were assured, and all the procedures were performed in compliance with relevant laws and institutional guidelines.

## Ethics approval of the study

The study was approved by the Institutional Ethics Committee of the Faculty of Physical Therapy, Cairo University, Egypt (No: P.T.REC/012/002400) and followed the Helsinki Declaration of 1975, as revised in 2000 for procedures involving human participants, and with a Trial registration: ClinicalTrials.gov Identifier: [NCT04004949](https://clinicaltrials.gov/ct2/show/study/NCT04004949).

## Inclusion and exclusion criteria

Inclusion criteria were as follows: (i) all the selected patients were analyzed and referred from a neurologist as having a stroke with onset at least 5 months, (ii) the upper extremity spasticity was ranging from grades I to III according to Modified Ashworth Scale [16], (iii) upper limb recovery stages III and IV according to Brunnstrom, and (iv) all patients body mass index (BMI) ranged from 20 to 30 kg/m<sup>2</sup> [17], with the age ranged from 45 to 60 years. Exclusion criteria were as follows: (i) difficulty to communicate or to understand test instructions, (ii) other conditions that caused upper extremity pain (for example supraspinatus or bicep tendinitis, frozen shoulder, fibromyalgia, and arthritis), (iii) complete motor disability of the upper extremity, and (iv) severe depression or other post-stroke



psychiatric symptoms (pathologic crying, pathologic laughter, apathy, and isolated fatigue).

#### Sample size

Sample size calculation was performed prior to the study using G\*POWER statistical software (version 3.1.9.2; Franz Faul et al. [18], Universitat Kiel, Germany) and revealed that the minimum required size of each group was 26. The primary outcome measure is SBA. The calculations were made using  $\alpha = 0.05$ ,  $\beta = 0.2$ , and large effect size = 0.8 and allocation ratio  $N2/N1 = 1$ . The large effect size was used as it yielded a realistic sample size.

#### Procedures

##### Evaluation of scapular dyskinesia

The horizontal distance of the scapular from the thoracic spine was measured using the palpation meter (PALM) (Performance Attainment Associate, St. Paul, MN, USA).

The lateral scapular slide test (LSST) was utilized to assess the scapular dyskinesia. LSST included three static positions performed bilaterally: at 0° (with the arms adducted), 45° (with hands-on-hips), and 90° (abduction with the arms raised in inward rotation). The patient testing position was sitting with his hip and knee in loose situated at 90° of flexion and with uncovered shoulders, on a seat with a short back.

The shoulder moved in abduction actively or passively with therapist assistance. One tip of the PALM was put on one of the marked inferior angles of the scapula, and the other tip was moved to reach the marked corresponding spinous process and then the reading was taken, and this step was repeated three times for the every three previous positions, to be confirmed. The same steps were performed on the other side. Both sides' readings were recorded, and the differences between them were calculated in each position. The bilateral difference of 1.5 cm considered the limit for choosing

whether scapular asymmetry is abnormal, as the separation of 1.5 cm greater than the contralateral side in any position recommended scapular dyskinesia [6].

The measurements obtained with the LSST are considered reliable and valid as the Kibler’s test interrater reliability is moderate to fair for physical therapists and physicians in assessing scapular positioning or asymmetry (dyskinesia) [6].

**Measurement of scapular balance angle (SBA)**

The scapular position was determined through the measurement of SBA. The patient’s position was remaining with his arms holding at both the side of the pelvis, the scapula inferior angle on the two sides was checked, and a line was drawn interfacing these marks. Another vertical line was drawn somewhere in the range of cervical (C7) and thoracic (T10) spinous process. The angles formed by the line interfacing both inferior angles of the scapula with the vertical line going through the spine [14].

The absolute difference between these two angles referred to the SBA [14]. In normal non-affected subjects, the values for the SBA were  $2.505 \pm 2.340^\circ$  while the abnormal results were with an angle greater than  $7.185^\circ$ . An intraobserver intraclass correlation coefficient (ICC) of 0.87 and interobserver ICC of 0.84 was reported. SBA manual measurement is viewed as a straightforward and reproducible evaluation of the position of the scapula in clinical practice [14].

**Evaluation of upper extremity sensorimotor functions**

Fugl-Meyer Assessment upper extremity (FMAUE) scale used to evaluate the sensorimotor capacity of the upper extremity. FMAUE is viewed as valid and reliable for the evaluation of stroke patients [19]. The intra-rater reliability was high for the motor and sensory scores (0.95–1.0) [20]. The motor scores of the upper extremity going from 0 points (no active motion) to 66 (full active movement) and the score of the exteroceptive and proprioceptive sensations range from 0 to 12. The most reduced and most noteworthy scores present the more terrible and better capacity separately. Every item of the FMAUE incorporated 3 points for every test, a zero score was given if the patient did not apply the assignment, and a score of 1 was given if the task performed was incomplete and a score of 2 for the complete execution of the task; however, the reflex was estimated utilizing just 2 points, with a score of 0 nonappearances or 2 for the presence of reflex.

The equipment & tools needed for FMAUE were as follows: a seat, table, bed, stopwatch, and hammer for reflex assessment, ball of cotton, pencil, paper, little can, tennis ball, and a blindfold. The motor assessment included reflex action, flexor and extensor synergies of the upper extremity, movement combining synergies, development out of synergies, wrist strength, and coordination/

speed as a finger to nose test. The sensory assessment procedures included light touch and proprioception sensation with open then closed eyes for (shoulder, elbow, wrist, and thumb).

FMAUE motor scale scores classified as “no to poor” upper extremity capacity was < 31, while “limited capacity” represented 32 to 47, “notable capacity” was 48 to 52, and “full” upper extremity capacity was 53 to 66 [21].

**Data analysis**

General characteristics for the patients were compared between both groups using a *t* test. Comparison of sex, type of stroke, recovery stages, affected side, and spasticity grade distribution between groups was carried out using the chi-squared test. The unpaired *t* test was used for comparison of LSST, SBA, and FMAUE between both groups, *p* < 0.05 represented the significance level. All statistical analysis was led through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

**Results**

**Patient’s characteristics**

The mean ± SD of patients’ characteristics and duration of illness of groups A and B demonstrated in Table 1.

**Table 1** Basic characteristics of all participants

	Group A	Group B	<i>p</i> value
	$\bar{X} \pm SD$	$\bar{X} \pm SD$	
<b>Age (years)</b>	53.23 ± 5	54.43 ± 5.6	0.38
<b>BMI (kg/m<sup>2</sup>)</b>	26.2 ± 3.06	25.46 ± 3.05	0.35
<b>Duration of illness (months)</b>	7.3 ± 1.31	7.53 ± 1.38	0.5
<b>Sex</b>			
Male	12 (52%)	14 (40%)	0.39
Female	18 (48%)	16 (60%)	
<b>Types of stroke</b>			
Ischemic	14 (47%)	18 (60%)	0.3
Hemorrhagic	16 (53%)	12 (40%)	
<b>Affected side</b>			
Right	13 (43%)	14 (47%)	0.79
Left	17 (57%)	16 (53%)	
<b>Spasticity</b>			
Grade I	1 (3%)	2 (7%)	0.6
Grade I <sup>+</sup>	6 (20%)	8 (27%)	
Grade II	15 (50%)	10 (33%)	
Grade III	8 (27%)	10 (33%)	
<b>Recovery stage “Brunnstrom”</b>			
Stage III	23 (77%)	20 (67%)	0.39
Stage IV	7 (23%)	10 (33%)	

$\bar{x}$  mean, *SD* standard deviation, *p* value level of significance

The results showed that between both groups, there was no significant difference in the mean age, BMI, and duration of illness ( $p > 0.05$ ). Also, there was no significant difference in the distribution of sex, type of stroke, affected side, spasticity grades, and recovery stages between both groups ( $p > 0.05$ ).

**LSST for scapular dyskinesia**

There was a significant increase in LSST of group A at 0, 45, and 90° shoulder positions compared with that of group B ( $p = 0.001$ ) (Table 2).

**Effect of scapular dyskinesia on SBA and FMA-UE**

There was a significant increase in SBA of group A compared with that of group B ( $p = 0.001$ ). There was a significant decrease in motor and sensory FMA-UE scores of group A compared with that of group B ( $p = 0.001$ ) (Table 3).

**Discussion**

The results of the present study indicated that the hemiparetic upper extremity for group A with scapular dyskinesia showed a significant decrease in motor and sensory FMA-UE scores and a significant increase in SBA compared with that of the group B with no scapular dyskinesia. These findings outlined the significant effect of scapular dyskinesia on scapular position and sensorimotor function of the upper extremity. The asymmetry of scapular position is principal because of it changes the capacity of the muscles that control the scapula.

The scapula acts as a steady base for the motion of the arm. During arm movement, the muscles show a feed-forward or expectant control action to guarantee that the scapular position is adjusted to the position of the humerus [22]. A sufficient positioning of the scapula is needed for the productivity of the powerful movement of the shoulder [23]. During motor functional tasks of the upper extremity the patients with stroke had a decreased capacity to perform isolated and particular arm motions due to the awkward nature of scapulohumeral muscles and scapulothoracic coordination [11]. Defect in the scapular posture cause changes in the length and

muscle strength of the shoulder region that alters the mechanics of the glenohumeral joint [24].

The absence of retraction presented with the scapular dyskinesia causes loss of balance with arm elevation, and the lack of scapular protraction around the chest increases the deceleration of the powers at the shoulder joint and changes in the glenoid and the humerus connection [25]. In stroke patients, the scapular asymmetry is due to winging as well as tipping (scapula makes tracks in an opposite direction from the thorax because of the absence of scapular steadiness by the serratus anterior), this happens principally because of gravitational powers [26]. There is a decrease of subacromial space in scapular dyskinesia [27] and a decline in rotator cuff power [28]. Rotator cuff weakness may debilitate motor control and greater mechanical damage of the subacromial space structures [29].

The result of this study is in agreement with the findings of Hou [30] who supported that spastic scapular dyskinesia leads to impaired shoulder active and passive ROM after stroke. A study by Dabholkar et al. [31] also supported and agreed with the present study results as it investigated the scapular dyskinesia on 50 stroke patients and the results showed that the scapular dyskinesia was evident in 64% of patients, and the SBA was  $\leq 4$  in 24% of patients, 5 to 7° in 50% of patients, and  $> 7^\circ$  in 26% of patients, while the stroke disability assessment scale showed 19 patients with mild disability, 24 with moderate disability, and 7 patients with severe disabilities. Scapular poor steadiness, position, and arrangement, on the chest affect the accessible scope of movement of the shoulder which may subsequently block function utilization of the upper limb.

Scalha et al. [32] demonstrated a direct connection between the FMA and with light touch exteroceptive sensation in the arm, elbow, and hand with Nottingham Tactile Appraisal. De Baets et al. [11] recommended that due to loss of particular muscle activation after the stroke that leads to changes in the scapular and glenohumeral stabilizers, the synchronized activation of shoulder force couple is very important for motor control of the shoulder, framed by the upper trapezius, lower trapezius, and serratus foremost to upward pivot the scapula [22].

Joshi and Naik [33] reported that in stroke patients, the scapula was pulled in descending revolution by gravity. The patients' posture of forward trunk flexion permits scapula elevation on the thorax and fortifies scapular descending pivot. The direction of the glenoid fossa changes with the goal that it was confronting descending as opposed to face upward, forward, and outward. This changed position of scapula influences the glenohumeral scope of movement and motor elements of the upper limb in stroke patients.

**Table 2** Comparison of LSST between groups A and B

	Group A	Group B	MD (95% CI)	T value	p value
	$\bar{X} \pm SD$	$\bar{X} \pm SD$			
<b>LSST (cm)</b>					
<b>0°</b>	1.81 ± 0.2	0.9 ± 0.29	0.91 (0.78-1.03)	14.13	0.001 <sup>a</sup>
<b>45°</b>	2.15 ± 0.33	1 ± 0.3	1.15 (0.98- 1.3)	14.22	0.001 <sup>a</sup>
<b>90°</b>	2.45 ± 0.3	1.21 ± 0.21	1.24 (1.1-1.36)	18.62	0.001 <sup>a</sup>

LSST lateral scapular slide test,  $\bar{x}$  mean, SD standard deviation, MD mean difference, CI confidence interval p value level of significance, <sup>a</sup>Significant

**Table 3** Comparison of SBA and FMAUE between groups A and B

	Group A $\bar{x} \pm SD$	Group B $\bar{x} \pm SD$	MD (95% CI)	T value	p value
<b>SBA (degrees)</b>	9.43 ± 1.86	4.03 ± 1.37	5.4 (4.55–6.24)	12.73	0.001 <sup>a</sup>
<b>FMAUE</b>					
<b>Motor</b>	35.23 ± 3.61	48.86 ± 7.01	– 13.63 (– 16.51– – 10.57)	– 9.46	0.001 <sup>a</sup>
<b>Sensory</b>	7.1 ± 1.4	9.1 ± 1.24	– 2 (– 2.68– – 1.31)	– 5.85	0.001 <sup>a</sup>

SBA scapular balance angle, FMAUE Fugl-Meyer assessment upper extremity,  $\bar{x}$  mean, SD standard deviation, MD mean difference, CI confidence interval p value level of significance, <sup>a</sup>Significant

Kibler et al. [6] stated that the scapular muscle fatigue and scapular muscle imbalance or weakness may lead to changes of glenohumeral proprioception (deep sensation), muscular inhibition, impaired coordination, and timing of movements are considered causes for scapular dyskinesia. Also, the proprioceptive dysfunction and injury to the joint can alter sensory information provided by mechanoreceptors which can lead to scapular dyskinesia.

The sensorimotor framework is characterized as the combination of tactile and motor systems that required in keeping up joint steadiness. The proprioception is responsible for arranging and adjustment of motor directions and changing places of the joints required to represent the complex mechanical cooperation inside the musculoskeletal framework [34]. The findings of the examination by Turgut and Baltaci [35] indicated that the dynamic developments of the scapula required control of the neuromuscular system and sensorimotor framework combination for the capacity to effectively put the hand and upper limb in the space.

DePalma and Johnson [36] noticed that scapular poor balance, position, and arrangement on the chest would influence fundamentally the shoulder scope of movement and subsequently decline the upper extremity functional activity. Park et al. [37] expressed that the scapula influences the shoulder joint and has a significant contribution to altering its position. Additionally, a report by Park et al. [37] endorsed that reinforcing the scapular stabilizer muscles could avoid scapula dyskinesia which thusly improves the capacity in the upper limb in stroke patients. Likewise, Park et al. [37] and Hardwick and Lang [9] affirmed the significance of the management of scapular position alternation to improve the upper extremity capacity of stroke patients.

Sanjukta et al. [38] stated that scapular dyskinesia produces abnormal synergistic movements of the scapula during arm raising activity and prevents the upper limb normal motor functioning of the affected side and restricts the scapular normal movements [39]. Some variables could influence the strength of the limb, for example, feedback loops including mechanoreceptors of joint and musculotendinous that are coordinated by the neurological system, and the proprioceptive loops, which

is viewed as the particular variety of sensory methodology of touch and envelops the joint movement (kinesthesia) sensation and joint position sense [40].

Scapular dyskinesia may bring about the incredible impact on sensorimotor, tactile capacities, and daily functions, likewise influencing the joint position sense because of disturbance of ordinary neuromuscular reflex joint adjustment, as any adjustments in the articular mechanoreceptors would bring out sensory inputs that decrease the sensitivity of muscle spindle and hence diminishing proprioception, which show that the role of the proprioceptive system in keeping the shoulder balance and functional activities [41].

The results of the present study explained the impact of scapular dyskinesia on upper-limb sensorimotor function and scapular position. This study provides quantitative measurements of both variables. Most of the previous studies concentrate on the effect of scapular dyskinesia on motor function while this study includes the assessment of the sensory domain also. The finding of this study may direct the attention of the clinician to attempt to prevent the development of scapular dyskinesia in patients with hemiplegia and highlights the importance of early rehabilitation of scapular muscles as a base to restore the upper extremity functions.

There are some limitation in this study, as the electromyography (EMG) studies of scapular muscles were not included in the investigation. X-ray for glen-humeral joint and scapulothoracic joint articulation was not included in the assessment of scapular alignments. For future studies, it would be beneficial to include these assessment methods in the investigation of the effect of scapular dyskinesia on the spine or other neurological conditions.

## Conclusion

Based on the findings of this study, we can conclude that a high score of scapular dyskinesia had a great effect on the scapular balance angle and upper extremity sensorimotor function in a spastic stroke patient. So that the scapular dyskinesia management should be considered in the rehabilitation program for stroke patients with spasticity.

### Abbreviations

EMG: Electromyography; FMA: Fugl-Meyer Assessment; FMAUE: Fugl-Meyer Assessment upper extremity; ICC: Correlation coefficient; LSST: Lateral scapular slide test; PALM: Palpation meter; SBA: Scapular balance angle

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### Authors' contributions

LS and SM collected all the measurements data. SM analyzed and interpreted the patient data regarding the disease. LS was a major contributor in writing the manuscript. The authors read and approved the final manuscript.

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### Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to current Cairo University regulations and Egyptian legislation but are available from the corresponding author on reasonable request and after institutional approval.

### Ethics approval and consent to participate

All the patients received verbal and written information about the study and gave written consent to participate, before the beginning of the study. The anonymity and confidentiality were assured, and all the procedures were performed in compliance with relevant laws and institutional guidelines. The study was approved by the Institutional Ethics Committee of the Faculty of Physical Therapy, Cairo University, Egypt (No: P.T.REC/012/002400) and followed the Helsinki Declaration of 1975, as revised in 2000 for procedures involving human participants, and with a [ClinicalTrials.gov](https://clinicaltrials.gov) ID NCT04004949.

### Consent for publication

All the patients received verbal and written information about the study and gave written consent to participate, before the beginning of the study. The anonymity and confidentiality were assured, and all the procedures were performed in compliance with relevant laws and institutional guidelines.

### Competing interests

The authors declare that they have no competing interests.

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