Effects of Scapular Stabilization Training on Trunk Control and Upper Limb Function in Chronic Stroke Patients: A Case Report

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Purpose This study aimed to investigate the effects of scapular stabilization training (SST) on trunk control and upper limb function in a patient with chronic stroke. ***Methods*** This case study involved a 53-year-old female patient with right-sided hemiplegia following a left basal ganglia infarction. The intervention was conducted over four weeks, five sessions per week, for a total of 20 sessions, with each session lasting 60 minutes. Outcome measures included the trunk impairment scale (TIS) to assess trunk control, the reaching performance scale for stroke (RPSS) to evaluate reaching performance and compensatory movements, and the fugl-meyer assessment for the upper extremity (FMA-UE) to assess upper limb motor function. All assessments were performed before and after the intervention under the same conditions. ***Results*** This study demonstrated improvements in dynamic sitting balance and trunk coordination following scapular stabilization training, with a 3-point increase in the total TIS score. Reaching performance also improved, as reflected by increased RPSS scores and reduced compensatory trunk movements during both near and far reaching tasks. In addition, upper limb motor function improved, with a 6-point increase in the total FMA-UE score. ***Conclusion*** The findings of this case study suggest that scapular stabilization training may be an effective intervention in contributing to improvements in trunk control, reducing compensatory movements during reaching, and enhancing upper limb function in a patient with chronic stroke.

Key words Chronic stroke, Scapular, Trunk control, Upper limb function

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Ⅰ. Introduction

Stroke is a major cerebrovascular disease caused by an interruption of cerebral blood flow due to ischemia or hemorrhage, resulting in deprivation of oxygen and nutrients to brain tissue.[1)] Such central nervous system damage leads to a wide range of neurological functional impairments, among which upper extremity motor dysfunction is one of the most common sequelae, occurring in approximately 49–59% of patients during the early stage after onset.[2)] Impairments in upper extremity motor function restrict activities of daily living (ADLs) related to reaching, grasping, and manipulating objects.[3)] Upper extremity motor dysfunction after stroke arises from muscle weakness, spasticity, and abnormal movement patterns.[4)] Motor recovery of the upper extremity following stroke is generally classified into acute, subacute, and chronic stages. In the chronic stage, stroke patients commonly adopt compensatory strategies characterized by excessive trunk movements and abnormal scapular motions during reaching tasks.[5,6)] Although these compensatory movement strategies may initially enable task performance, prolonged reliance on them reduces the use of the elbow, wrist, and hand, leading to joint deformities and muscle shortening. Furthermore, such strategies limit the recovery of isolated movements, ultimately restricting functional recovery of the upper extremity.[7)]

The scapula serves as a critical link between the trunk and the upper extremity, providing both stability and mobility to facilitate functional arm movements. In individuals with chronic stroke, weakness of the periscapular muscles and abnormal muscle recruitment

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result in altered scapular alignment and reduced scapulohumeral rhythm.[8,9] In particular, weakness of the upper trapezius, lower trapezius, infraspinatus, serratus anterior, and anterior deltoid impairs coordination, leading to inefficient movement patterns.[10] This scapular instability is defined as scapular dyskinesis,[11] which contributes to reduced shoulder range of motion, inefficient muscle activation, and shoulder pain.[6]

Additionally, due to the influence of gravity, the scapula in stroke patients is often pulled into downward rotation, accompanied by trunk inclination toward the non-paretic side, resulting in asymmetric trunk alignment.[9] This decline in postural control of the trunk further limits scapular and shoulder joint mobility during reaching and grasping tasks.[12]

Therefore, restoration of scapular stability, mobility, and efficient scapulohumeral rhythm is essential for improving upper extremity motor function in individuals with chronic stroke. However, previous studies have primarily focused on fine motor training of the hand or the reduction of compensatory strategies, and research directly facilitating scapular movement while analyzing trunk control and upper extremity function in an integrated manner remains limited. Accordingly, the purpose of this study was to investigate the effects of scapular stabilization training on trunk control and upper extremity function in individuals with chronic stroke.

II. Methods

1. Participant

This study was conducted as a single-case study involving one 53-year-old female patient with stroke who was hospitalized at B Hospital in Gyeonggi Province, Republic of Korea. The participant visited the emergency department on June 22, 2023, after experiencing dizziness and difficulty maintaining balance while walking. Following radiological examinations, she was diagnosed with a left basal ganglia infarction, which resulted in right-sided hemiparesis. Cognitive function was assessed using the Korean version of the Montreal Cognitive Assessment (K-MoCA), with a score of 29 points, confirming that the participant was able to understand verbal instructions and perform the required tasks without difficulty (Table 1). The participant was able to ambulate indoors and outdoors with caregiver assistance; however, limitations were observed during movements that required displacement beyond the base of support (BOS).

Table 1. General characteristics of the subject.

Variables	Subject
Gender	Female
Diagnosis	Left basal ganglia infarction
Age(year)	53
Onset(months)	17
K-MoCA(score)	29
Medical history	Hypertension, Hyperlipidemia

K-MoCA: korean version of the montreal cognitive assessment

2. Study Design and Intervention

This study employed a single-case A–B design conducted between October 17, 2024, and November 16, 2024. The intervention was administered five times per week for four consecutive weeks, totaling 20 sessions, with each session lasting 60 minutes. The effects of the intervention were evaluated by comparing pre- and post-intervention outcomes. Outcome measures included postural alignment, the Trunk Impairment Scale (TIS), the Reaching Performance Scale for Stroke (RPSS), and the Fugl–Meyer Assessment for the Upper Extremity (FMA-UE). All assessments were performed under identical environmental conditions. Baseline assessments were conducted prior to the initiation of the intervention, and post-intervention assessments were completed after the four-week intervention period.

2–1. Scapular Stabilization Training

The scapular stabilization training implemented in this study was designed to facilitate scapular movement and promote recovery of efficient scapulohumeral rhythm in a seated position. To ensure trunk and pelvic stability, the therapist adjusted pelvic alignment by controlling anterior tilt, posterior tilt, and lateral tilt so

(A) (B) (C)

Figure 1. Scapular stabilization training in a sitting position

that the bilateral anterior superior iliac spines (ASIS) and posterior superior iliac spines (PSIS) were aligned horizontally. Subsequently, the therapist guided the scapula on the affected side to align parallel to the trunk and spine at the level of the second to seventh thoracic vertebrae, while simultaneously facilitating external rotation of the humerus during reaching movements. The participant was instructed to recognize scapular protraction, retraction, upward rotation, and downward rotation, as well as humeral external rotation, and to apply these movements during reaching tasks through repetitive intervention (Figure 1).

3. Outcome Measures

3-1. Postural Alignment Analysis

Postural alignment was assessed in both sitting and standing positions using digital photography with a standardized protocol. To ensure measurement consistency, the camera distance and height were predetermined and kept constant across all assessments. In the sitting position, photographs were obtained from the posterior view to evaluate spinal alignment and bilateral scapular symmetry, whereas in the standing position, photographs were obtained from the anterior view to assess vertical alignment and left–right postural symmetry. All recordings were conducted in the same location under identical environmental conditions. For visual comparison of postural alignment, a vertical reference line was applied to the images, and deviations from left–right symmetry were highlighted using red lines.

3-2. Trunk Impairment Scale (TIS)

The TIS is an assessment tool developed to evaluate trunk function in individuals with stroke and measures trunk control and balance abilities.[13] The TIS consists of three subdomains: static sitting balance, dynamic sitting balance, and trunk coordination. It comprises a total of 17 items, with a maximum possible score of 23 points, where higher scores indicate better trunk function. The TIS has demonstrated high reliability in individuals with stroke, with excellent intra-rater reliability (intraclass correlation coefficient [ICC] = 0.96) and inter-rater reliability (ICC = 0.99).[13]

3-3. Reaching Performance Scale for Stroke (RPSS)

The RPSS is a clinical assessment tool developed to evaluate compensatory movements observed during reaching tasks in individuals with stroke. The RPSS assesses performance during tasks directed toward a close target and a far target by observing trunk displacement, movement smoothness, shoulder movements, elbow movements, prehension, and overall performance (global score). Each component is rated on a 4-point scale ranging from 0 to 3. The maximum scores are 18 points for the close-target task and 18 points for the far-target task, yielding a total possible score of 36 points. Higher scores indicate less use of compensatory strategies and more efficient reaching performance. The RPSS has demonstrated excellent

test-retest reliability in individuals with chronic stroke (ICC = 0.98).[14]

3-4. Fugl-Meyer Assessment for the Upper Extremity (FMA-UE)

The FMA-UE is a standardized assessment tool used to evaluate motor function, balance, sensation, and joint function in individuals with stroke. The FMA-UE consists of 33 items, including 18 items assessing shoulder, elbow, and forearm function, 5 items for wrist function, 7 items for hand function, and 3 items for coordination. Each item is scored on a 3-point ordinal scale, with 0 indicating no function, 1 indicating partial function, and 2 indicating normal function. The maximum total score is 66 points. The FMA-UE has demonstrated excellent inter-rater reliability in individuals with stroke (ICC = 0.98).[15]

Ⅲ. Results

1. Changes in Alignment in Sitting and Standing Positions

To analyze changes in postural alignment, markers were placed on the seventh cervical vertebra (C7) and the inferior angles of both scapulae in sitting and standing positions before and after the intervention. Prior to the intervention, the trunk demonstrated rotational misalignment relative to the midline, accompanied by asymmetrical pelvic height and anterior displacement of the right scapula, resulting in an overall asymmetric posture. In addition, the right scapula exhibited a statically elevated and anteriorly tilted position (Figures 2A, 2C). After the intervention, weight-bearing was more evenly distributed based on the ischial tuberosities, and trunk rotational alignment was reduced. Correspondingly, changes in the position of the inferior angle of the right scapula and improvements in bilateral alignment were observed. The participant also reported a reduction in shoulder pain following the intervention (Figures 2B, 2D).

2. Changes in TIS, RPSS, and FMA-UE Scores Before and After the Intervention

In this study, no change was observed in the static sitting balance score of the TIS, which remained at 7 points before and after the intervention. In contrast, the dynamic sitting balance score increased by 2 points, from 5 points before the intervention to 7 points after the intervention, while the trunk coordination score increased by 1 point, from 5 to 6 points. Consequently, the total TIS score increased by 3 points, from 17 to 20 points.

For the RPSS, improvements were observed across

(A) (B) (C) (D)

Figure 2. Changes in sitting and standing posture before and after the intervention.
(A),(B) Sitting posture before and after the intervention. (C),(D) Standing posture before and after the intervention.

Table 2. Comparison of changes in TIS, RPSS, FMA-UE before and after intervention

Variables			Pre-intervention	Post-intervention	Changes
TIS	Static sitting balance		7 point	7 point	0 point
	Dynamic sitting balance		5 point	7 point	2 point
	Coordination		5 point	6 point	1 point
	Total		17 point	20 point	3 point
RPSS	Trunk displacement	Close target	2 point	3 point	1 point
		Far target	1 point	3 point	2 point
	Movement smoothness	Close target	1 point	2 point	1 point
		Far target	1 point	1 point	0 point
	Shoulder movements	Close target	2 point	3 point	1 point
		Far target	1 point	2 point	1 point
	Elbow movements	Close target	2 point	3 point	1 point
		Far target	1 point	2 point	1 point
	Prehension	Close target	2 point	3 point	1 point
		Far target	2 point	2 point	0 point
	Global score	Close target	1 point	2 point	1 point
		Far target	1 point	1 point	0 point
	Total	Close target	10 point	16 point	6 point
		Far target	7 point	12 point	5 point
FMA-UE	Shoulder, Elbow, Forearm		24 point	26 point	2 point
	Wrist		7 point	9 point	2 point
	Hand		10 point	11 point	1 point
	Coordination/ Speed		4 point	5 point	1 point
	Total		45 point	51 point	6 point

TIS : trunk impairment scale, RPSS : reaching performance scale for stroke, FMA-UE : fugl-Meyer Assessment of the upper extremity

multiple components. Trunk displacement scores increased from 2 to 3 points in the close-target task and from 1 to 3 points in the far-target task. Movement smoothness improved from 1 to 2 points in the close-target task, whereas no change was observed in the far-target task. Shoulder movement scores increased from 2 to 3 points in the close-target task and from 1 to 2 points in the far-target task. Elbow movement scores also increased from 2 to 3 points in the close-target task and from 1 to 2 points in the far-target task. Prehension performance improved from 2 to 3 points in the close-target task. Accordingly, the total RPSS score increased by 6 points, from 10 to 16 points, for the close-target task and by 5 points, from 7 to 12 points, for the far-target task.

In the FMA-UE, scores for the shoulder, elbow, and forearm items increased from 24 to 26 points. Wrist function scores improved from 7 to 9 points, hand function scores increased from 10 to 11 points, and coordination scores increased from 4 to 5 points. Overall, the total FMA-UE score increased by 6 points, from 45 to 51 points (Table 2).

Ⅳ. Discussion

This single-case study investigated the effects of scapular stabilization training on trunk control and upper

extremity function in an individual with chronic stroke. The findings of this study demonstrated that following the application of scapular movement facilitation training, dynamic trunk control and upper extremity function improved, while compensatory movements during reaching tasks were reduced in a patient with chronic stroke.

With respect to changes in the TIS, no improvement was observed in static sitting balance; however, improvements were noted in dynamic sitting balance and trunk coordination. In individuals with stroke, weakness of the scapular stabilizing muscles on the affected side limits the ability to effectively support the weight of the upper limb, leading to alterations in scapular anatomical alignment and orientation.[16] In addition, the influence of gravity combined with asymmetric trunk posture continuously pulls the scapula downward, resulting in asymmetric trunk alignment and spinal deformity.[9] Normal scapular alignment reduces the load on the upper extremity, and strengthening of the periscapular muscles contributes to supporting the weight of the arm and maintaining an upright trunk posture, thereby exerting a positive effect on trunk control.[17] Park et al. (2021) reported improvements in upper extremity function and trunk control following periscapular muscle training in individuals with chronic stroke.[18] These findings suggest that strengthening and improving alignment of the scapular musculature may contribute to enhanced trunk control in this population. Improvements in the RPSS were observed in both close-and far-target tasks, including reductions in trunk displacement, as well as enhanced shoulder and elbow movements and overall reaching performance. During reaching, the scapula facilitates efficient upper extremity movement by maintaining the optimal length of the rotator cuff muscles through the force-couple actions of periscapular muscles such as the upper trapezius, lower trapezius, and serratus anterior.[19] However, individuals with stroke often exhibit excessive shoulder elevation to lift the arm and employ compensatory trunk displacement to advance the hand forward.[6] These movement strategies may be interpreted as compensatory responses resulting from insufficient force generation by weakened upper extremity muscles, leading to excessive recruitment of other muscles and the trunk.[20] Park et al. (2024) reported that scapular mobility training improved scapular alignment and upper extremity movement in individuals with chronic stroke.[21] Accordingly, scapular stabilization training may serve as an effective intervention to reduce compensatory trunk strategies and enhance efficient upper extremity movement during reaching tasks. Improvements observed in the FMA-UE, including shoulder, elbow, wrist, and hand function, suggest that enhanced scapular alignment and stability may positively influence not only proximal but also distal upper extremity movements. The FMA-UE is a clinical assessment designed to reflect the degree of abnormal muscle synergies and to evaluate the ability to perform isolated interjoint movements.[22] In individuals with stroke, inefficient scapular movement reduces humeral external rotation,[23] which may be attributed to the inability to position the scapula appropriately during arm elevation, thereby preventing the rotator cuff muscles from achieving an optimal length–tension relationship. Song et al. (2023) reported significant improvements in upper extremity function following scapulohumeral training in individuals with stroke, further supporting the clinical importance of improving scapular alignment and stability.[24] Overall, the findings of this study indicate that scapular stabilization training may facilitate independent control of the trunk and upper extremity, reduce compensatory movement strategies, and improve upper extremity function in individuals with chronic stroke. However, this study has limitations due to its single-case design, which restricts the generalizability of the findings. In addition, changes in scapular movement were not quantitatively measured. Future studies should include larger sample sizes and employ kinematic analyses and imaging-based assessments to objectively verify changes in scapular and trunk movement. Furthermore, comparative investigations examining the effects of scapular stabilization training in individuals with acute and subacute stroke are warranted.

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