Effects of Postural Control Enhancement with Trunk Stability on Upper Extremity Function in Stroke: A Case Report

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Purpose This study aims to investigate the effects of trunk stability on enhancing postural control and its effects on upper limb function in stroke. ***Methods*** This study was designed as a single-case research, with interventions provided 3 times a week for a duration of 3 weeks. Evaluations to assess the effectiveness of the intervention included changes in body posture alignment based on analysis of posture alignment, functional reach test (FRT), postural assessment scale for stroke (PASS), and manual function test(MFT). ***Results*** There was an improvement in overall body alignment, becoming more symmetrical. Additionally, the results from the PASS, FRT, and MFT indicate significant enhancements in the subject postural control, and upper extremity function following the intervention. ***Conclusion*** Improved trunk stability positively affects upper extremity function in stroke patients by helping maintain the body's center of gravity.

Key words Stroke, Trunk stability, Postural control, Upper extremity function

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Ⅰ. Introduction

A stroke is a disease caused by cerebral infarction or hemorrhage, leading to the interruption of nutrient and oxygen supply to the brain, which results in various neurological symptoms.[1)] Among these symptoms, the most common is muscle weakness on the paralyzed side, which can also affect the trunk muscles. This results in a limitation in shifting the center of gravity towards the paralyzed side, causing patients to support their weight on the non-paralyzed side. Consequently, this leads to difficulties in postural control, asymmetric posture, and reduced physical movement, which limit activities of daily living.[2,3)] To address these problems in stroke patients, improving postural control abilities is important. Enhancing postural control is a fundamental factor for maintaining the trunk vertically during voluntary movements and is essential for performing activities of daily living(ADLs).[4)] Therefore, improving postural control is considered one of the key goals in neurorehabilitation of stroke patients. Trunk stability is attained by activating the muscles of the trunk and symmetrically shifting body weight, aiding in keeping the body upright. This upright position reduces the spread of forces across spinal segments, contributing to a stable posture that enhances the functional movement of limbs.[5)] Marshall & Murphy(2005) stated that to enhance trunk stability, training of the abdominal, lower back, and pelvic muscles is necessary. It's important to activate muscles on both the surface and deeper within the body for proper posture. This includes the surface muscles such as the rectus abdominis(front of the abdomen), erector spinae(along the spine), and the oblique muscles of the abdomen, as well as deeper muscles like the transverse abdominis(deep abdominal muscle) and multifidus(deep spinal muscle). These muscles work together to assist in stabilizing the spine and core.[6)] Fundamentally, activating the trunk muscles to symmetrically shift body weight reduces body sway, thereby enabling more precise limb movements and ultimately leading to improved functional limb functionality.[7)] De Baets et al.(2016) re-

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ported that stroke patients exhibit increased ipsilateral axial rotation of the trunk when using their arms, which leads to changes in the activation patterns of the upper limb muscles. Consequently, a compensatory mechanism is suggested to occur in order to maintain shoulder function.[8] This indicates that enhancing postural control must precede improvements in upper limb function in stroke patients, requiring an improvement in trunk stability. Therefore, this study aims to investigate the effect of improved postural control through trunk stability on the upper limb function of stroke patients.

II. Materials and Methods

1. Research subject

This study was conducted on a single 38-year-old male patient hospitalized at B Hospital located in Gyeonggi-do. subject was diagnosed with hypertension(HTN) 5 years ago but did not receive medication treatment. On June 29, 2021, after dinner, subject suddenly complained of a headache and visited the emergency room, where subject was diagnosed with intracerebral hemorrhage(ICH) in the right basal ganglia and intraventricular hemorrhage(IVH), leading to left hemiplegia. He scored 30 on the Korean-montreal cognitive assessment(K-MOCA), indicating he could understand and follow verbal instructions from the researcher(Table 1). Under the guidance of a caregiver, the subject was capable of walking both indoors and outdoors. However, it was observed that he found dynamic activities that required moving beyond his base of support(BOS) difficult. Prior to initiating the study, the researcher thoroughly explained the purpose and content of the study to subject and the carer and proceeded after obtaining their consent.

Table 1. General characteristics of the subject.

Variables	Subject
Gender	Male
Diagnosis	Lt. hemiplegia due to Rt. bassal ganglia ICH and IVH
Hx	HTN
Age(year)	38
On set\(months)	4
K-MOCA(score)	30

K-MOCA: korean-montreal cognitive assessment, ICH : intracerebral hemorrhage, IVH : intraventricular hemorrhage. Hx : history taking, HTN : hyperention

2. Research design

This study, conducted with a single-case A-B design from October 28th to November 15th, 2021, involved interventions 3times a week for 3weeks, resulting in nine 50-minute sessions. The same intervention methods were consistently applied over the three weeks. Evaluations to assess the intervention's effectiveness focused on comparing pre-and-post intervention changes, including body posture alignment, the postural assessment scale for stroke (PASS), the functional reach test (FRT), and the manual function test (MFT) for stroke.

3. Research tools

1) Analysis of posture alignment

The alignment in sitting and standing postures was evaluated using a digiral camera.To ensure accurate assessment, the distance and height of the digital camera were consistently selected and maintained. Furthermore, to minimize errors in posture alignment, the analysis of both sitting and standing postures was conducted in the same location.

2) Postural assessment scale for stroke (PASS)

PASS is a recently developed scale to assess balance, trunk control, and the ability to maintain equilibrium with postural changes in stroke patients. It comprises a total score of 36, divided into two main categories and 12 items. The scale includes three basic postures: lying, sitting, and standing. These are further divided into five items for posture maintenance ability and seven items for posture changing ability. Each item is scored from a minimum of 0 to a maximum of 3 points. The posture maintenance items include sitting without support, standing with support, standing without support, standing on the non-paralyzed leg, and standing on the paralyzed leg. The posture changing items include turning from supine to the paretic side laterally, turning from supine to the non-paretic side

laterally, moving from supine to sitting up on the edge of the mat, transitioning from sitting on the edge of the mat to supine, changing from sitting to standing up, moving from standing to sitting down, and standing to pick up a pencil from the floor.[9)]

3) Functional reach test (FRT)

FRT is used to measure the maximum distance one can reach forward while standing with stable base, providing insights into balance control during dynamic activities. In this test, the participant starts by standing with the elbow extended and the shoulder joint flexed at 90 degrees. The measurement begins at the end of the third metacarpophalangeal joint, and the maximum reach is recorded three times to calculate the average distance. During the test, the posterior tilt of the hip joint and pelvis and bending of the knee joint should not occur.[10)]

4) Manual function test (MFT)

MFT for stroke is an assessment tool developed to measure upper limb function and movement ability in stroke patients. It consists of eight items categorized into three main areas: upper limb movement, grasping, and finger manipulation. Scores are recorded as 1 point for each successfully completed task and 0 points for tasks that cannot be performed, with a total score of 32 points.[11)]

5) Intervention for trunk stability

In this study, the intervention adapted and enhanced the exercise method originally proposed by KILINÇ (2016), focusing on trunk stability training. The exercises were carried out in a sequence of positions, starting with semi-supine, then sitting, and finally standing.[5)]

5)–1. Trunk stability training in a semi–supine position

The participant is positioned on a Bobath table with two-thirds of their femur on the mat, while both feet are placed on the floor. The hip joint is realigned to ensure the lengthening of the hip flexor and abdominal muscles, aiming to achieve overall alignment of the posture(Figure 1A). The shoulder girdle is then realigned and its muscles are lengthened, preparing for a reaching movement by stimulating the triceps brachii and inducing protraction and retraction of the scapula. This movement focuses on promoting independent movements of the trunk and shoulder(Figure 1B). The abdominal muscles are activated during the reaching movement, with attention to prevent compensatory actions in the hip flexor muscles(Figure 1C).

(A) (B) (C)

Figure 1. Trunk stability training in a semi-supine position

(A) Posure alignment, (B) Reaching movement training, (C) Trunk muscle activation through reaching movement

Figure 2. Trunk stability training in a standing position

Figure 3. Trunk stability training in a sitting position

5)-2. Trunk stability training in a sitting position

The participant places their arms on the table on either side while sitting upright to prevent trunk collapse. To promote activation of the erector spinae and multifidus muscles, the therapist touches the posterior superior iliac spine(PSIS) and then induces anterior and posterior tilting movements of the pelvis. Care is taken to ensure that excessive compensatory shoulder elevation does not occur during this process(Figure 2).

5)-3. Trunk stability training in a standing position

To prevent trunk flexion or excessive use of the upper limbs, the participant repeats the action of sitting down and standing up from a position where the hip joints are higher than the knee joints, using bilateral arm reaching. The purpose of this process is to facilitate the carryover of activation between the trunk extensor and abdominal muscles through the reaching movements(Figure 3).

Ⅲ. Result

1. Changes in Sitting and Standing Posture Alignment

In this study, to analyze changes in the participants' posture before and after the intervention, accurate markings were made on the seventh cervical vertebra(C7) and the inferior angles of both scapulae for comparison. Pre-intervention, the trunk was rotated from the midline, which was noticeable by an asymmetrical alignment due to a variation in pelvic height and the forward displacement of the left humeral head, leading to malalignment of the scapulae's inferior angles. Post-intervention, there was a shift in

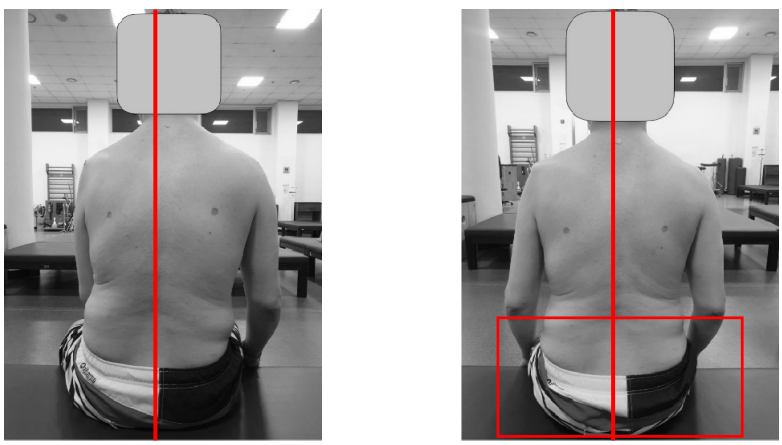

Figure 4. Changes in Sitting Posture Before and After the Intervention

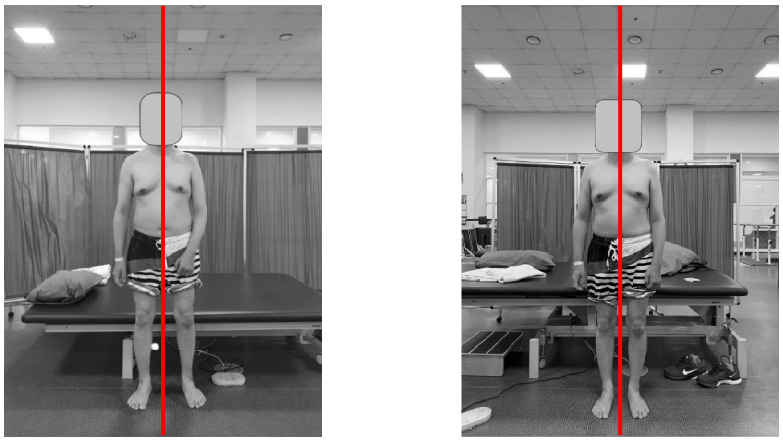

Figure 5. Changes in Standing Posture Before and After the Intervention

the position of the left scapula's inferior angle and a balanced distribution of weight on the ischial tuberosity(Figure 4). In the standing posture before the intervention, there was a visible asymmetry in the trunk muscles due to the external rotation of the paralyzed side knee joint and excessive weight bearing on the non-paralyzed side, which resulted in an increased associated reaction of the paralyzed arm. After the intervention, there was an increase in the activation of the abdominal muscles, weight bearing on the paralyzed side, and a reduction in the associated reaction of the paralyzed arm(Figure 5).

2. Comparison of changes in functional reach test(FRT), postural assessment scale for stroke (PASS), and manual function test(MFT) before and after intervention.

The PASS was measured as 32 points before intervention and 35 points after intervention. There were improvements in two specific items: a 2-point improvement on the non-paralyzed side and a 1-point improvement on the paralyzed side, resulting in a total improvement of 3 points. The results of the FRT showed that before intervention, the average reach distance was 20.5cm, with individual measurements of 17cm, 23cm, and 21.5cm. After intervention, the average reach distance increased to 26.6cm, with individual measurements of 26cm, 28cm, and 25.8cm, indicating an average improvement of 5.1cm. MFT was no change in the non-paralyzed side scores before the intervention, but there was an improvement in scores from 10 to 13 on the paralyzed side. In the detailed categories, there was an improvement of 1 point each in raising the upper limb forward, raising the upper limb to the side, and placing the palm to the back of the head (Table 2).

Table 2. Comparison of changes in functional reach test(FRT), postural assessment scale for stroke(PASS), and manual function test(MFT) before and after intervention.

Variables		Pre-intervention	Post-intervention	Changes
FRT		21.5cm	26.6cm	5.5cm
PASS	Standing on non affected leg	1point	3point	2point
	Standing on affected leg	1point	2point	1point
MFT	forward elevation	3point	4point	1point
	lateral elevation	3point	4point	1point
	occipital with the palm	2point	3point	1point

FRT : functional reach test, PASS : postural assessment scale for stroke, MFT : manual function test.

Ⅳ. Discussion

This study aimed to investigate the effect of postural control enhancement with trunk stability on upper extremity function in stroke patients. Shumway-Cook (2001) highlighted the importance of maintaining and controlling the center of gravity during the transition from a static posture, like sitting or standing, to a dynamic one involving voluntary movements.[12] In other words, to facilitate functional movement of the arms, initial activation of trunk muscles is essential, which in turn can reduce body sway.[7] In normal adults, balance is regained through the activation of leg and trunk muscles within 100-150milliseconds during perturbations. However, stroke patients have a longer reaction time to these perturbations compared to healthy individuals, and the strength of muscles used for balance recovery is reduced, increasing their risk of falling.[3]

According to previous research, before body movement occurs, activation of deep trunk muscles like the transverse abdominis and multifidus precedes. Particularly, the transversus abdominis consistently activates first, regardless of the direction of body movement. Furthermore, trunk stabilization training in stroke patients aimed at activating the transversus abdominis, external oblique, and internal oblique abdominal muscles, has been reported to improve scores in static and dynamic balance.[13,14] In this study, to investigate the enhancement of postural control ability through trunk stabilization, overall body alignment changes were first observed. Using the Postural assessment scale for stroke (PASS), scores improved from 32points before intervention to 35points after, with detailed score improvements being 2 points in standing on the non-paralyzed side and 1 point in standing on the paralyzed side. Additionally, the Functional reach test(FRT) showed an average increase from 20.5cm before intervention to 26.6cm after, an average increase of 5.1cm. Previous studies have revealed that trunk stabilization training reduces shear force between spinal segments through activation of abdominal and spinal muscles, aiding in aligning the trunk vertically and improving weight shift to the paralyzed side, thereby enhancing the ability to maintain the body's center of gravity.[15] This led to a reduction in associated reactions in the paralyzed arm. These results seem to positively affect postural control; however, to better understand the mechanism of muscle activation affecting trunk stabilization, subsequent research should consider adopting objective assessment tools like electromyography.

Improved postural control influences upper limb movement. In healthy adults, when lifting an arm, as the range of motion increases, the activation of the erector spinae, rectus abdominis, external oblique, and internal oblique muscles continuously increases throughout the entire range. This is because, as the arm is raised above 90 degrees, the center of gravity of the upper limb shifts backwards, generating a counteracting force.[16] In another previous study, it was found that upper limb movement was more efficient when trunk movement was temporarily restricted to enhance stability. It was noted that providing stability to the trunk and shoulder structures is effective in improving upper limb movements.[13,17] According to a study by Baets et al.(2016), stroke patients used more ipsilateral axial rotation when using their arms, resulting in delayed activation and earlier termination of the serratus anterior muscle, and a change in the recruitment pattern of the lower trapezius and infraspinatus muscles was observed.[18] In this study, after enhancing postural control through trunk stabilization, the Manual function test(MFT) for the stroke-affected upper limb showed an increase in scores from 10 to 13 on the paralyzed side. The detailed improvements included 1 point each for lifting the upper limb forward, lifting the upper limb to the side, and moving the palm to the back of the head. This suggests that enhancing postural control through trunk stabilization plays a crucial role in improving arm movement in upper limb function. The increase in the range of arm movement can be interpreted as activation of the trunk muscles to offset the backward shift of the center of gravity.

This study investigated the effects of postural control enhancement with trunk stability on upper extremity function in Stroke Patients for Hemiplegia in

Stroke, concluding that improvements in trunk stability positively affect upper limb function. However, the study is limited by its single-case design, involving only one participant, making it challenging to generalize the findings to the broader stroke patient population. Additionally, the study did not account for any treatment or interventions the participants may have received during the day, so the impact of daily treatments on the results cannot be ignored. Future research should address these concerns by selecting participants under more stringent criteria and conducting systematic studies that include interventions not previously applied.

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