VALIDITY OF THE STROKE-BALANCE EVALUATION SYSTEMS TEST (S-BESTEST) IN PEOPLE WITH CHRONIC STROKE

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ความเที่ยงตรงของแบบประเมิน Stroke-Balance Evaluation Systems Test (S-BESTest) ในผู้ป่วยโรคหลอดเลือดสมองระยะเรื้อรัง

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VALIDITY OF THE STROKE-BALANCE EVALUATION SYSTEMS TEST (S-BESTEST) IN PEOPLE WITH CHRONIC STROKE

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BY

KANOKPICH SATAYAPRAKORB

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The Stroke-Balance Evaluation Systems Test (S-BESTest) is a reliable and valid system-based assessment of balance impairments in patients with subacute strokes. Patients with chronic and acute strokes have different movement and balance characteristics, according to rates of neuromuscular recovery, secondary complications, and the use of compensatory strategies. However, the S-BESTest has not been validated among people with chronic strokes. Therefore, this study aimed to examine the concurrent validity of the S-BESTest in people with chronic strokes. The method included rater training and reliability testing, which were performed before the validity test. Then, three physical therapists examined the performances of the patients from the same set of ten video clips on two separate occasions, performed 10 days after the first occasion. The scores from the first and second occasions were used to determine intra-rater reliability using the intraclass correlation coefficient (ICC) model 3.1. There were 20 participants with chronic strokes assessed with balance assessment tools including the S-BESTest, the Berg Balance Scale (BBS), and the Community Balance and Mobility Scale (CB&M). Concurrent validity was assessed with the BBS and the CB&M using Pearson's Product-Moment Correlation. The statistical significance was set at a p-value of <0.05. The ceiling and floor effects were calculated by percentage, frequency of the lowest or highest possible scores achieved by participants. The results were as follows: the intra-rater reliability of the total and domain scores of the S-BESTest were excellent with an ICC (95% CI) of 0.96-0.99 (0.85-0.99) and 0.93-1.00 (0.71-1.00), respectively. The S-BESTest had an excellent correlation with the BBS ($r = 0.93$, $p<0.01$) and the CB&M ($r = 0.86$, $p<0.01$). The results showed no floor and ceiling effects of the S-BESTest in people with chronic strokes, while the BBS showed the trend of the floor effect (10%) and 15% of participants had very low scores on the CB&M. In conclusion, the S-BESTest was reliable, but clear instructions of how to score. Rater practice and discussing the session with an experienced physical therapist are necessary for such a degree of the reliability of the S-BESTest. The S-BESTest was valid in assessing balance problems and the test items were challenging enough, but not too difficult for patients with chronic strokes who live in the community.

Keyword : Stroke, Postural control, Balance assessment, Psychometric properties

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CHAPTER 1
INTRODUCTION

Background

Stroke is the second leading cause of death and the second most common cause of disability-adjusted life-years (DALYs). [1] Stroke is also one of the top ten leading cause of death [2] and the second cause of DALYs in Thai population. [3]

The most common deficit after stroke is motor impairments. [4, 5] It is known that functional balance problems can be affected by multiple systems, such as sensory deficit, cognitive impairment, biomechanical constraints, and impaired movement strategies. [6-8] A study reported that about 83% of stroke survivors suffered from balance impairment [9] which was an important fall risk factor in patients with stroke. [10, 11] Consequence of falls in patients with stroke result in fracture, soft tissue injury, activity limitation, increased dependence, and fear of falling. [12, 13] Identification of balance problems and their underlying impaired systems may help guide specific training for stroke survivors. Therefore, individuals with stroke should be evaluated for balance ability. [14, 15]

In clinical setting, the Berg Balance Scale (BBS) is a reference tool for assessing functional balance problems in patients with stroke. [16] This is a reliable measure to detect static and dynamic sitting and standing balance. [17] The BBS score showed strong correlation with-scores from Timed Up and Go Test (TUG) (r = -0.70). [18] However, the BBS is not appropriate for evaluation in persons with chronic stage after stroke because it has a ceiling effect (47.7%). [18] The Community Balance and Mobility Scale (CB&M) is a tool for assessing balance and mobility deficits that affect their engagement in the community. The CB&M is developed to be used in persons with moderate to high function after stroke. [18] Nineteen tasks of the CB&M are mobility and advanced balance activities, such as walk, look and carry, descending stairs, and walking with looking. [19] The CB&M is valid to assess functional balance and mobility in patients with chronic stroke as it showed strong correlation with-scores from the BBS and TUG (r = 0.83 and -0.75, respectively). [18] Moreover, the CB&M is sensitive to detect changes of patients' performance (Standardized Response Mean (SRM) = 0.83) with no significant floor-ceiling effects in chronic stroke survivors with moderate to mild balance and mobility impairments. [18] Regarding the systems approach for balance evaluation, the impairments of physiological systems (i.e., sensory-musculoskeletal systems, neuromuscular-sensory strategies, and internal representations) and mechanisms (adaptive and anticipatory mechanisms) underlying postural control problems are mainly focused [20] in order to determine the underlying causes of the balance deficit for specific and effective treatment. [8] However, the BBS and CB&M do not cover various systems of postural control as they assess only stability in gait and anticipatory postural adjustment. Therefore, these 2 scales cannot provide specific impairment of systems underlying functional balance problems.

The Balance Evaluation Systems Test (BESTest) is one of clinical balance tests that uses a systems approach to characterize the underlying causes for impaired balance control. The BESTest is a 36-items tool comprising 6 domains of postural control assessment including biomechanical constraints, stability limits/verticality, anticipatory postural adjustments, postural responses, sensory orientation, gait stability, and the cognitive involvement in gait. [21] The BESTest is a good measurement to evaluate balance in stroke patients in subacute and chronic phases. [22-24] However, multiple items of the BESTest required long administration time (30-45 minutes estimated time to complete) that can limit its practicality in the clinic. [21] Moreover, there are concerns with redundancy of items and many items of subsystems have not found to be sensitive in disclosing balance impairments in patients with chronic stroke. [22] Therefore, newly balance assessment tools that used the system approach has been developed, including Mini-Balance Evaluation Systems Test (Mini-BESTest), [25] Brief-Balance Evaluation Systems Test (Brief-BESTest), [26] and Stroke-Balance Evaluation Systems Test (S-BESTest). [27]

The Mini-BESTest has been developed to focus on dynamic balance and can be complete in 10 minutes. [25] The Mini-BESTest demonstrated good internal consistency, excellent reliability and validity with no significant floor-ceiling effects in patients with chronic stroke. [28] However, the 14-items Mini-BESTest contains items with only four of six domains from the original BESTest which is incomprehensive for postural control. [25] Importantly, 3-items of this, compensatory stepping correction in a backward and a lateral directions and standing on foam surface with eyes closed showed fair reliability in patients with chronic stroke. [28]

The Brief-BESTest has been developed and retained the theoretical basis of the original BESTest through its 8-items covering all six balance subsystems. The time to complete the Brief-BESTest is less than 10 minutes resulting in a more feasibility of this scale in clinical testing. [26] The Brief-BEStest showed good reliability and validity with no significant floor-ceiling effects in patients with chronic stroke. [29] However, the Brief-BESTest showed a fair intra-rater reliability of hip/trunk lateral strength when used in chronic stroke patients. [29] Stability in gait domain of the Brief-BESTest contains only one item which is TUG. [28] This TUG cannot reflect a more complex problem such as when encounter a challenge cognition-motor interaction, thus, the TUG scores also exhibited a ceiling effect in chronic stroke patients. [18, 30]

The S-BESTest is a short version of the BESTest aimed to reduce the assessment time, the less necessary, and duplicate items through 13 items of the 6 domains of the BESTest. [27] The S-BESTest was validated in patients with subacute stroke. Results demonstrated excellent reliability (inter-rater reliability Intraclass Correlation Coefficient (ICC) = 0.86-0.99, intra-rater reliability ICC = 0.95-0.98), validity (concurrent validity of S-BESTest with BBS = 0.95), internal responsiveness (SRM = 1.28-1.29) with high sensitivity, specificity, and post-test accuracy, and neither floor or ceiling effects. [27] Compared with the Brief-BESTest, the S-BESTest can evaluate all systems of postural control that is related to balance while standing and walking in real situation, such as TUG with dual task, change in gait speed, and walk with head turn. [27] A previous studies showed stability in gait problems in patients with chronic stroke i.e., a significant decrease in velocity, stride length, and step length while walking with dual task condition, [31] difficult to change in gait speed, [32] and alter body orientation or head position when turning a corner or turning the head. [33] These problems reported in people with chronic stroke would be revealed by using the S-BESTest, suggesting the feasibility of using the S-BESTest in patients with chronic stroke. Nowadays, an evidence showed that recovery of performance after stroke not limit to 3 months (golden period), but it can extend to 6 to 18 months. [34] Therefore, rehabilitation for improving motor and balance performance not only important for subacute stage after stroke but also in chronic stage. The use of a valid tool will help guide physical therapists to design treatments that are specially with impaired systems underlying functional balance problem. Therefore, the validation of the S-BESTest in people with chronic stroke is a significant process before applying a tool in clinic.

Research question

How was the concurrent validity of the S-BESTest in persons with chronic stage of stroke?

Objective of the study

To assess the concurrent validity of the S-BESTest with the BBS and CB&M in people with chronic stage of stroke.

Hypotheses of the study

The S-BESTest would be highly correlated with the BBS and CB&M ($r>0.8$).

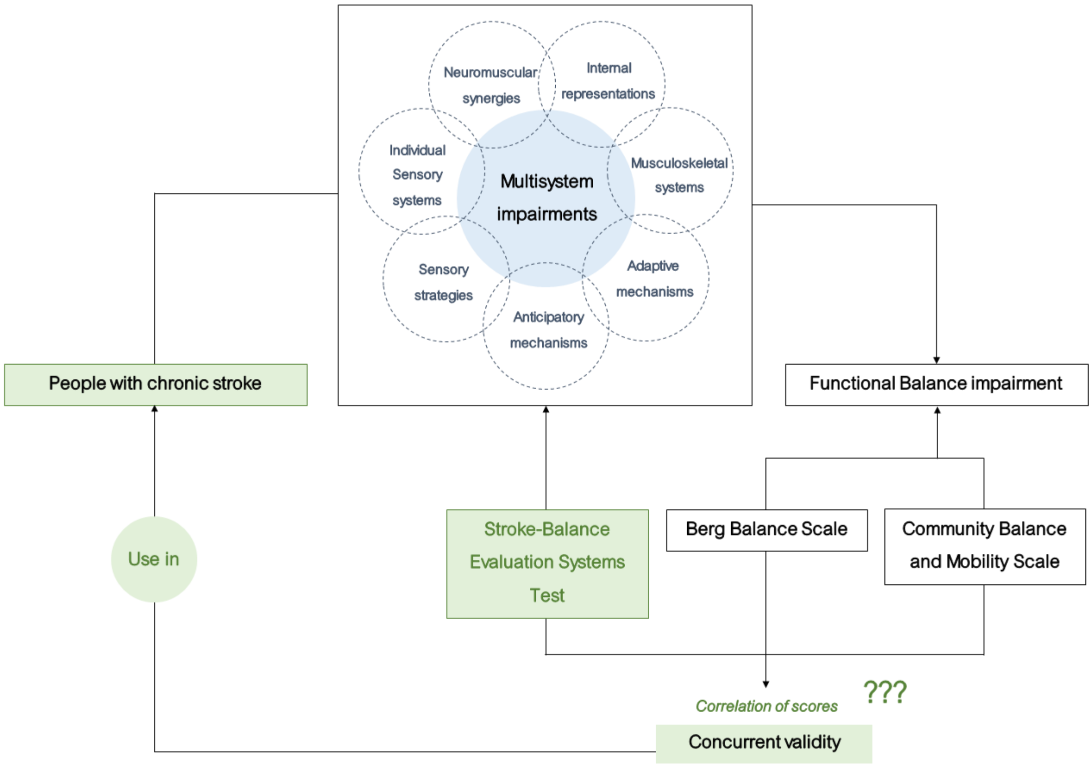
Significant of the study

One of the major problems found in patients with stroke is balance impairment which is an important fall risk factor. Identification of balance problems and their underlying impaired systems can help guide specific training. The S-BESTest can be used to characterize the underlying causes for impaired balance control in patients with stroke in subacute phase faster than the use of the original BESTest. This study has been expanded the benefit of the S-BESTest in clinical practice. Findings from this study would encourage the clinicians to use the S-BESTest in people with chronic stroke in order to gain comprehensive information on balance impairments.

Keywords

Stroke, Postural control, Balance assessment, Psychometric properties

Conceptual framework



CHAPTER 2
THE LITERATURE REVIEW

The review of literatures is divided into four major parts as follows: 1 stroke and physical function deficit; 2 impairments underlying balance problem in patients with stroke; 3 balance assessment methods; and 4 evaluation of measurement properties.

Stroke and physical function deficit

Stroke is defined by the World Health Organization (WHO) as "a clinical syndrome consisting of rapidly developing clinical signs of focal (or global in case of coma) disturbance of cerebral function lasting more than 24 hours or leading to death with no apparent cause other than a vascular origin". [(35)] A study in Burden of Disease Research Program showed that the prevalence of stroke in Thailand was 6,950 per 100,000 persons. [(3)] The absolute number of in-patient with stroke for the whole country was 25.7 million in 2013 [(36)] and increased to 80.6 million stroke survivors in 2016. [(37)] Aims of stroke rehabilitation is to help patients recover their functional movements, balance, and ability to participate in everyday life activities. [(38)]

There are 2 mains type of stroke: ischemic stroke and hemorrhagic stroke. Ischemic stroke is the main type of stroke which is accounted for 87% of all strokes. [(39)] The ischemic stroke occurs when there is a narrowing of the arteries or blood supply of the brain is blocked by blood clots. [(40)] Hemorrhagic stroke occurs when a blood vessel in your brain leaks or ruptures [(39)] as a result of many conditions that affect blood vessel, i.e., uncontrolled high blood pressure, overdose of anticoagulants, and aneurysms. [(40)]

Stroke can cause many problems. Common impairments after stroke are impaired motor function in upper and lower limbs, sensory deficit, urinary incontinence, dysphagia, cognitive impairment, dysarthria, visual field defect, dysphasia, visual neglect, and sensory inattention. [(4)] Among those impairments, impaired motor function, poor functional balance performance, and cognitive function are the most common problems found in patients with stroke. [(4)] Moreover, recurrent stroke showed highly significant risk factor for long-term disability. [(41)] As a results of impaired body function, patients with stroke have problem with balance deficit that can further a cause of participation restriction such as using public transportation by themselves. [42] However, appropriate medical intervention can limit brain damage and rehabilitation strategy helps improve body function and regain functional activities and participation. [41]

Post-stroke recovery has been divided into two components including truly change in body structures and functions to a state before onset of stroke and improvement of functional activities and participation due to the interaction of poststroke plasticity mechanisms and sensorimotor training. [43] Considering timeline after stroke, there are four stages [34, 43] i.e., hyper-acute, acute, subacute, and chronic. Hyper-acute (0-24 hours after stroke onset) is a period of brain cell death or hematoma expansion. [43] Management during hyper-acute (such as thrombolytics [44] or thrombectomy [45]) is to limit further cellular damage that is important for restoration of brain function. Acute phase (1-7 days after stroke onset) is period of inflammatory process and beginning of endogenous plasticity. [43] Starting rehabilitation program during the acute phase is to improve impairments and functions of body structure. [46] Subacute phase is divided to 2 sub-phases, i.e., early subacute (7 days - 3 months after stroke onset) and late subacute (3 - 6 months after stroke onset). [43] Neuroplasticity, the adaptive modifications of neural networks in response to anatomical or functional deficit, [47] is significantly occurs during 3-6 months after stroke onset. [48, 49] Therefore, during the late subacute stroke is considered a critical time window to recover patients' ability to perform functional movement activities. [48-50] Chronic phase is divided into early chronic (6-18 months after stroke onset) and late chronic (more than 18 months after stroke onset). Recent research showed that rehabilitation program enables motor recovery and improvement of performance in activities of daily living, even in the chronic stage. [34] Thus, rehabilitation is important for all stages of stroke recovery to help patients achieve a good quality of life and independent living. Rehabilitation efforts in individuals with chronic stroke do not treat neurological impairments but emphasize compensatory rehabilitation programs for reduce activity limitations and participation restriction using some compensatory strategies and control of environment factor. [35, 51]

Impairments underlying balance problem in patients with stroke

Definition of balance

Balance is an ability to maintain the body of a person not to fall. [52] Balance impairment is a disturbance when standing or walking affect to that make to unsteady. [53]

Postural control is a term used to describe a complex motor skill for controlling the body position while perform activities including unpredictable situation and external perturbation. [54] Postural control consists of two components: postural orientation (posture) and postural equilibrium (balance). [20] Postural orientation is defined as the ability to controlling of body alignment with environment. [20] Postural equilibrium or postural stability is defined as the ability to control stability between the center of mass within base of support during change of body position or external triggered. [52] These abilities are a foundation of the ability to stand, walk, or perform any movement in environment without fall. According to system model of motor control, there are multiple body systems are responsible for normal posture and balance performance that are sensory-musculoskeletal systems, neuromuscular-sensory strategies, internal representations, adaptive and anticipatory mechanisms. [55] A disorder in any one or many components of postural systems showed increase risk of balance problem and falls. [20]

Balance impairment in patients with stroke

Reported that about 83% of stroke survivors suffer from balance impairment. [11] Balance impairment influence decrease ability of walking performance, such as decrease gait speed, step length, and increase the limited of stability. [56] All these related to risk of falls. [57]

Major factors that affected to balance impairment in patients with stroke including motor and sensory impairments. [58, 59] Muscle weakness and impair the ability to control movement of legs [60, 61] and trunk muscles [62] are very commons impairment in after stroke. These problems cause patients with stroke loss their stability in standing position by themselves. [58, 60, 62] Impairment of sensory systems including somatosensory, visual, and vestibular systems suffered to re-weight sensory information.

[20] Previous study showed that patients with chronic stroke could not stand on an unstable support surface with eyes closed and opened. [63] It indicated that impaired sensory organization for balance is an impairment underlying affect to limited of functional activity, such as standing and walking with various environment including unstable surface or in darkness. [59] Impairment of neuromuscular-sensory strategies affect to patients with stroke loss the ability to recovery their body center of mass within base of support in response to external perturbation. [20] Moreover, patients with stroke have problems with performing a cognitive-motor dual task, such as lowing gait speed when they performed walking while counting numbers. [64] All these impairments can cause patients lack of the ability to maintain stable body balance in daily activities, as a result, they may have slip and fall injury. [12, 65]

Balance assessment methods

Balance assessment is process of identifying an existing of balance problem, determining cause of balance problem, assessing fall risk, and determining effectiveness of treatment program. [66] Various types of balance assessment tools have been developed and used in research field and rehabilitation. Measurement properties of balance assessment tools, such as reliability and validity are usually considered by clinicians and researchers in order to select a relevant tool for assessing an aspect of balance in a specific target population. Technological tools and clinical scales for balance and their measurement properties in patients with stroke are mainly described in this review. [66]

Technological tools

Computerized posturography and inertial sensor-based assessment are two main technological devices for assessing postural control problems. [67-69] The computerized posturography is faceplate-based device that can assess in static and dynamic balance with organize sensory information and external balance perturbation. [70] Computerized posturography is quantitative outcome measures in laboratory offer greater precision and potential to detect subtle or subclinical balance impairment. [8] However, computerized posturography is relatively expensive and requires extensive training and testing. [66] The inertial sensor-based is a technological devices base on Miniaturized Inertial Measurement Units or Magneto Inertial Measurement Units that typically includes accelerometers, gyroscopes, and magnetometers refer to a three-dimensional frame. [71] The inertial sensor-based assessment is using to analyze human postural sway through inertial sensors directly worn on the subject body. [69] The inertial sensor-based appropriate for assessing balance performance in patients affected by neurological disorders that reliable and accuracy. [71] However, inertial sensor-based provide using in laboratory setting. [69]

Clinical scales for balance assessment

Clinical scales for balance assessments can be categorized into functional balance assessment and systems balance assessment.

Functional balance assessment

Functional balance assessment is balance assessment that approach to patients' ability to perform a balance challenged activity, such as the ability to stand on one leg. There are many functional balance assessment scales developed for using in clinical setting for documenting balance status and changes with intervention because ease of use and do not require sophisticated equipment. [66, 72] The recommendation of functional balance measurement in chronic stroke patients consists of Postural Assessment Scale for Stroke (PASS), Dynamic Gait Index (DGI), and Berg Balance Scale (BBS), [73] as well as, the Community Balance and Mobility Scale (CB&M) is common use of clinical balance test in patients with chronic stroke. [18] All of them are performance-based outcome measures to assess a patient's current status provide a score, an interpretation of results. Benefits and limitations of clinical balance assessment scales regarding their psychometric properties (Table 1) are described below.

- **Postural Assessment Scale for Stroke (PASS)**

The PASS is developed for examine balance performance in stroke patients. [74] Items in the PASS are designed to assess patients' ability to maintain or change a given lying, sitting, or standing position in twelve tasks, such as sitting without support, standing with and without support, standing on one leg, standing up to sitting down, and standing with picking up a pencil from the floor. [74] Total score of the PASS is

36 points that each item score from “0”, indicated cannot perform, to “3”, indicated perform fully. It requires 10-20 minutes for administration. (74) The PASS showed excellent test-retest reliability (ICC = 0.93) (75) and internal consistency (Cronbach’s α = 0.94-0.96). (17) Likewise, the PASS demonstrated excellent concurrent validity with the BBS and Fugl-Mayer Assessment-Balance subscale (FMA-B) (r = 0.93 and 0.95, respectively) and convergent validity with Barthel Index (BI) (r = 0.92). (17) Furthermore, the PASS is sensitive detect to change balance performance between acute and chronic phases (SRM = 7.65) and subacute and chronic phases (SRM = 2.75) with no scale attenuation effect in stroke patients with chronic stage which is floor (3.8%) and ceiling effects (17.5%). (17) Although the PASS seem to be an appropriate scale for assessing balance in patients with chronic stroke, balance during walking is not included in this scale. (74)

- **Dynamic Gait Index (DGI)**

The DGI is developed to evaluate balance performance during gait with challenging tasks. The DGI consists of 8 items, such as walking while changing speed, walking while turning the head horizontally and vertically, walking with pivot turn, walking over and around obstacles, and stair climbing. The total score of DGI is 24 points. The score of each item ranges from “0”, indicate severe impairment, to “3”, indicate no gait dysfunction. It requires 10-15 minutes for administration. (76) The DGI showed test-retest and inter-rater reliability of total scores are excellent (ICC = 0.96 and 0.96, respectively) in patients with chronic stroke. (76) Moreover, the DGI showed moderate to excellent concurrent validity with the BBS (r = 0.83), TUG (r = -0.77), Timed Walking Test (TWT) (r = -0.73), and Activities-Specific Balance Confidence Scale (ABC) (r = 0.68) (76) and sensitive to detect change of performance in patients with chronic stroke (Effect size (ES) = 0.5 and SRM = 0.89). (77) However, the DGI is a useful clinical tool for assessing dynamic balance in ambulatory people with chronic stroke because this is performed during only over-ground walking. (76) Moreover, 3-items of this, gait with horizontal head turns, vertical head turns, and pivot turns, showed fair reliability in patients with chronic stroke. (76)

- **Berg Balance Scale (BBS)**

The BBS is a reference tool for assessing functional balance problems in patients with stroke (16, 17, 78, 79) that appropriate used assessment tool across the continuum from acute care to community-based care and a good understanding in addition to the psychometric test of the BBS in stroke patients in various periods are excellent. (16) The BBS consists of 14 functional tasks in everyday life (16) to detect static and dynamic sitting and standing balance. (17) It requires 15-20 minutes for administration. (16) A total score of BBS is 56 points. The score for each task ranges from "0", cannot perform, to "4", perform fully. (80) The BBS has excellent inter-rater and intra-rater reliability in patients with chronic stroke (ICC = 0.97 and 0.98, respectively) (77) and moderate to high correlations including concurrent validity with the FMA-B (r = 0.92) and PASS (r = 0.93), (17) convergent validity with the TUG (r = -0.70) (18) and CB&M (r = 0.83) (18) with sensitive to detect change of performance in patients with chronic stroke (ES = 0.44 and SRM = 0.81), (77) and predictive validity with the Chedoke-McMaster stroke assessment (CMSA) leg and foot and strength of paretic limb (r = 0.54, 0.50, and 0.50, respectively) (18) but strength of non-paretic limb showed poor correlations (r = 0.28). (18) Importantly, several studies of the BBS it has a ceiling effect after stroke more and more after onset 6 months (28.8%) and 8 months (47.7%), respectively (17, 18) that mean the BBS is not appropriate for evaluation balance in the chronic stage after stroke.

- **Community Balance and Mobility Scale (CB&M)**

The CB&M is a tool for assessing balance and mobility deficits that affect their engagement in the community. The CB&M is developed to be used in persons with moderate to high balance performance after stroke. (18) Nineteen tasks of the CB&M are mobility and advanced balance activities, such as walk, look and carry, descending stairs, and walking with looking. (19) This test requires 20-30 minutes to administration. A total score of CB&M is 96 points. The score for each task between from "0", cannot perform or is not attempt or perform with assistive device, to "5", perform fully. (19) The CB&M is valid to assess functional balance and mobility in patients with chronic stroke as it showed strong correlation with-scores from the BBS and TUG (r = 0.83 and -0.75, respectively) and moderate correlation with the CMSA leg and foot scores (r = 0.61 and 0.63, respectively) and the paretic limb strength (r = 0.67) whereas strength of non-paretic limb showed poor correlation (r = 0.46). [18] Moreover, the CB&M is sensitive to detect changes of patients' performance (SRM = 0.83) with no significant floor-ceiling effects in chronic stroke survivors with moderate to mild balance and mobility impairments. [18] However, assessments of many impairments affecting functional balance, e.g., impaired sensory organization for balance, biomechanical constrains, and the cognitive involvement in gait are not included in the CB&M. [19]

Systems balance assessment

Systems theory of postural control is including sensory-musculoskeletal systems, neuromuscular-sensory strategies, internal representations, adaptive and anticipatory mechanisms. [20]

Various types of assessment tools were developed base on this theory in order to characterize impairments of the underlying systems and mechanisms of functional balance problems. The assessment tools in group include the Balance Evaluation Systems Test (BESTest), Mini-Balance Evaluation Systems Test (Mini-BESTest), Brief-Balance Evaluation Systems Test (Brief-BESTest), and Stroke-Balance Evaluation Systems Test (S-BESTest). Components and measurement properties of each scale are described in this review (Table 2).

- **Balance Evaluation Systems Test (BESTest)**

The BESTest is one of systems approach that can identify the underlying of balance problem. The BESTest focus on systems approach including sensory-musculoskeletal systems, neuromuscular-sensory strategies, internal representations, adaptive and anticipatory mechanisms. [21] The BESTest consist of 6 domains which are evaluate on biomechanical constraints, stability limits/verticality, anticipatory postural adjustments, postural responses, sensory orientation, stability in gait, and cognitive involvement in balance performance. [21] Score of the BESTest consists of 108-points scoring each scored on a 4-point, ranging from "0", cannot perform, to "3", perform fully. [21] The BESTest showed excellent reliability (intra-rater and inter-rater reliability ICC = 0.93 and 0.98, respectively), excellent concurrent validity with the BBS (r = 0.78), and moderate convergent validity with the ABC (r = 0.59) in patients with chronic stroke. [22] Moreover, The BESTest is sensitive to detect changes of patients' performance (SRM = 0.9-1.2) with did not have floor-ceiling effects when assessed stroke patients. [23, 24] However, the multiple items of the BESTest are required the long administration time (30-45 minutes estimated time to complete) that can limit its practicality in the clinic. [21] Moreover, there are concerns with redundancy of items and many items of subsystems have not found to be sensitive in disclosing balance impairments in patients with chronic stroke. [22] Therefore, newly balance assessment tools that used the system approach has been developed that including Mini-BESTest, Brief-BESTest, and S-BESTest. [25-27]

- Mini-Balance Evaluation Systems Test (Mini-BESTest)

The Mini-BESTest has been developed from the BESTest focus on dynamic balance contains 14-items with only four of six domains from the original BESTest including anticipatory postural adjustments, postural responses, sensory orientation, and stability in gait. [25] The Mini-BESTest can be complete in 10 minutes. [25] Score of the Mini-BESTest consists of 28-points scoring each scored on a 3-point ordinal scale, ranging from "0", cannot perform, to "2", perform fully. [25] The Mini-BESTest demonstrated good internal consistency (Cronbach's α = 0.89-0.94), excellent intra-rater and inter-rater reliability (ICC = 0.97 and 0.96, respectively), and high significant correlations including the BBS (r = 0.83), TWT (r = -0.82), and strength of paretic limb (r = 0.83) with no significant floor-ceiling effects in community-dwelling individuals with chronic stroke. [28] However, the Mini-BESTest showed low to moderate correlation including Functional Reach Test (FRT) (r = -0.55), strength of non-paretic limb (r = 0.54), CMSA of leg and foot (0.53 and 0.64, respectively), ABC (r = 0.50), and Motor Assessment Scale (MAS) (r = -0.22). [28] Moreover, 3-items of this, compensatory stepping correction in a backward and a lateral directions and standing on foam surface with eyes closed, showed fair reliability in patients with chronic stroke. [28]

- **Brief-Balance Evaluation Systems Test (Brief-BESTest)**

The Brief-BESTest has been developed and retained the theoretical basis of the original BESTest through its 8-items covering all six balance subsystems. The time to complete the Brief-BESTest is less than 10 minutes resulting in a more feasibility of this scale in clinical testing. [26] Score of the Brief-BESTest consists of 24-points scoring each scored on a 4-point ordinal scale, ranging from "0", cannot perform, to "3", perform fully. The Brief-BESTest showed good intra-rater and inter-rater reliability (ICC = 0.97 and 0.98, respectively) and internal consistency (Cronbach's α = 0.81). [29] Moreover, the Brief-BESTest showed moderate to very strong correlations with the BBS (r = 0.87) and PASS (r = 0.91) with no scale attenuation effect in patients with chronic stroke. [29] However, the Brief-BEStest showed a fair intra-rater reliability of hip/trunk lateral strength (Kappa = 0.304) when used in chronic stroke patients. [29] Stability in gait domain of the Brief-BESTest contains only one item which is TUG. [28] This TUG cannot reflect a more complex problem such as when encounter a challenge cognition-motor interaction, thus, the TUG scores also exhibited a ceiling effect in chronic stroke patients. [18, 30]

- **Stroke-Balance Evaluation Systems Test (S-BESTest)**

The S-BESTest is short version of BESTest that contains 13 items of 6 domains including biomechanical constraints, stability limits/verticality, anticipatory postural adjustments, postural responses, sensory orientation, and gait stability which required 7-10 minutes of administration. Score of the S-BESTest consists of 39-points scoring each scored on a 3-point ordinal scale, ranging from "0", cannot perform, to "3", perform fully. [27] A study shown that excellent psychometric properties in individuals with subacute stroke. [27] Results demonstrated excellent reliability (inter-rater reliability ICC = 0.86-0.99 and intra-rater reliability ICC = 0.95-0.98), validity (concurrent validity of S-BESTest with the BBS = 0.95), internal responsiveness (SRM = 1.28-1.29) with high sensitivity (0.78), specificity (0.82-0.84), and post-test accuracy (80%), and neither scale attenuation effect. [27] Compared with the Brief-BESTest, the S-BESTest can evaluate all systems of postural control that is related to balance while standing and walking in real situation, such as TUG with dual task, change in gait speed, and walk with head turn. [27] The level of balance performance determined by the Fugl-Mayer Assessment-Lower Extremity subscale (FMA-LE) is indicated. The FMA-LE score of 0-14 indicated low balance performance and a score higher than 14 indicated high balance performance in patients with subacute stroke, [27] as well as, cut-off of the FMA-LE score at 21 points indicated high balance performance in patients with chronic stroke. [81] Motor function of lower extremity is important factor of functional balance performance. [58, 82] The S-BESTest showed its appropriateness to assess balance in patients with subacute stroke who had high or low balance performance. [27] This information indicates the potential of using the S-BESTest in patients with chronic stroke with varying lower extremity function and balance performance. [81]

Different types of assessment scales focus on different components of postural control system are showed in the Table 3.

Table 1 Psychometric properties of functional balance assessment tools in people with chronic stroke

Psychometric Properties	Clinical tools			
	PASS	BBS	CB&M	DGI
Reliability				
Internal consistency (α)	0.94-0.96	-	-	-
Intra-rater (ICC)	-	ICC 0.98	-	-
Inter-rater (ICC)	-	ICC 0.97	-	ICC 0.96
Test-Retest (ICC)	ICC 0.93	-	-	ICC 0.96
Validity				
Criterion-related				
Concurrent (r)	BBS: 0.93	PASS: 0.93	-	BBS: 0.83
	FM-B: 0.95	FMA-B: 0.92		ABC: 0.68
				TUG: -0.77
				TWT: -0.73

Table 1 (Continued)

Psychometric Properties	Clinical tools			
	PASS	BBS	CB&M	DGI
Validity				
Criterion-related (Continued)				
Predictive (r)	-	CMSA leg: 0.54 CMSA foot: 0.50 Paretic: 0.50 Non-paretic: 0.28	CMSA leg: 0.63 CMSA foot: 0.61 Paretic: 0.67 Non-paretic: 0.46	-
Construct				
Convergent (r)	BI: 0.92	TUG: -0.70 CB&M: 0.83	TUG: -0.75 BBS: 0.83	-
Discriminant (r)	-	-	-	-
Responsiveness	D14-180: SRM 7.65 D90-180: SRM 2.75	ES 0.44 SRM 0.81	D90-240: SRM 0.83	ES 0.5 SRM 0.89
Scale attenuation				
Floor effect	No (3.8%)	No (5%)	No (6.8%)	-
Ceiling effect	No (17.5%)	D180: 28.8% D240: 47.7%	No (0%)	-
Time to complete (min)	10 - 20	15 - 20	20 - 30	15 - 20

Note: α = Cronbach's alpha; ICC = Intraclass Correlation Coefficient; r = Correlation coefficient; SRM = Standardized response mean; D = Day; min = minutes; ES = Effect Size; PASS = Postural Assessment Scale for Stroke; DGI = Dynamic Gait Index; BBS = Berg Balance Scale; CB&M = Community Balance and Mobility Scale; FMA-B = Fugl-Meyer Assessment-Balance subscale; TUG = Timed Up and Go Test; TWT = Time Walking Test; CMSA = Chedoke-McMaster Stroke Assessment; BI = Barthel Index; ABC = Activities-Specific Balance Confidence Scale

Table 2 Psychometric properties of systems balance assessment tools in people with chronic stroke

Psychometric Properties	Clinical tools			
	BESTest	Mini-BESTest	Brief-BESTest	S-BESTest *
Reliability				
Internal consistency (α)	-	0.89-0.94	0.81	
Intra-rater (ICC)	0.93	0.97	0.97	0.95-0.98
Inter-rater (ICC)	0.98	0.96	0.98	0.86-0.99
Test-Retest (ICC)	-	-	-	
Validity				
Criterion-related				
Concurrent (r)	BBS: 0.78	BBS: 0.83 FRT: 0.55 paretic: 0.83 non-paretic: 0.54 TWT: -0.82	BBS: 0.87 PASS: 0.91	BBS: 0.95
Predictive (r)	-	-	-	-
Construct				
Convergent (r)	ABC: 0.59	CMSA leg: 0.53 CMSA foot: 0.64 MAS: -0.22 ABC: 0.50	CMSA leg: 0.59 CMSA foot: 0.55 FMA-LE: 0.66	-
Discriminant (r)	-	GDS: -0.17 AMT: 0.08	GDS: -0.15 MoCA: 0.44	-
Responsiveness	SRM: 0.9-1.2 *	-	-	SRM 1.28-1.29 sensitivity: 0.78 specificity: 0.82-0.84 accuracy: 80%

Table 2 (Continued)

Psychometric Properties	Clinical tools			
	BESTest	Mini-BESTest	Brief-BESTest	S-BESTest *
Scale attenuation				
Floor effect	No (0%) *	No (0%)	No (4%)	No (0%)
Ceiling effect	No (0%) *	No (0.9%)	No (0%)	No (11.4%)
Time to complete (min)	30 - 45	10 - 15	5 - 7	7 - 10

Note: α = Cronbach's alpha; ICC = Intraclass Correlation Coefficient; r =Correlation coefficient; min = minutes; SRM = Standardized response mean; BESTest = Balance Evaluation Systems Test; Mini-BESTest = Mini-Balance Evaluation Systems Test; Brief-BESTest = Brief-Balance Evaluation Systems Test; S-BESTest = Stroke-Balance Evaluation Systems Test; BBS = Berg Balance Scale; PASS = Postural Assessment Scale for Stroke; FRT = Functional Reach Test; TWT = Time Walking Test; CMSA = Chedoke-McMaster Stroke Assessment; FMA-LE = Fugl-Meyer Assessment-Lower Extremity subscale; ABC = Activities-Specific Balance Confidence Scale; MAS = Motor Assessment Scale; MoCA = Montreal Cognitive Assessment; GDS = Geriatric Depression Scale-Short Form, * indicated psychometric properties in patients with subacute stroke

Table 3 Summary of the different types of assessment scales focus on different components of postural control systems

Postural control systems	Musculoskeletal, sensory systems, and internal representations			Neuromuscular-sensory strategies and adaptive mechanism			
Components of balance assessment	I	V	II	III	IV	VI	VI with cognitive
Functional assessment							
BBS	X	X	X	/	X	/	X
CB&M	X	X	X	/	/	/	X
PASS	X	X	X	/	X	/	X
DGI	X	/	X	/	X	/	X
Systems assessment							
BESTest	/	/	/	/	/	/	/
Mini-BEStest	X	/	X	/	/	/	/
Brief-BESTest	/	/	/	/	/	/	X
S-BESTest	/	/	/	/	/	/	/

Note: I = Biomechanical constrains; II = Stability limit & internal representation of verticality; III = Anticipatory postural adjustment; IV = Reactive postural response; V = Sensory orientation; VI = Stability in gait; BESTest = Balance Evaluation Systems Test; Mini-BESTest = Mini-Balance Evaluation Systems Test; Brief-BESTest = Brief-Balance Evaluation Systems Test; S-BESTest = Stroke-Balance Evaluation Systems Test; BBS = Berg Balance Scale; PASS = Postural Assessment Scale for Stroke; DGI = Dynamic Gait Index; CB&M = Community Balance and Mobility Scale; / indicated item contains in component; X indicated item did not contains in component

Evaluation of measurement properties

Evaluation of measurement properties is one of process for consideration of good measurement. [83] Reliability and validity are important measurement properties of any assessment in clinic and a research. [83] The advantages using a good clinical assessment which is specific target populations and correspond with purpose for evaluate of individual's problem are ensuring of the results that reliable, accuracy, and efficacy imply to identified performance and eligible of treatment for individuals. [84]

Reliability

Reliability refers to how consistent a measurement is. If the same result can be achieved by using the same measurement tools and methods (test-retest reliability), rater (intra-rater and inter-rater reliability) the measurement is considered reliable. [85] Intra-rater reliability of a performance-based assessment scale can be determined by evaluation of correlation of two set of scores taken by same rater who rate patients' performance different time. [86] Inter-rater reliability of a performance-based assessment scale can be determined by evaluation of correlation of the scores taken by different raters who rate patients' performance at the same time. [86] A newly developed balance assessment scales are usually assessed these properties before using it in clinical setting.

Validity

Validity is the instrument's ability to measure what is intended to be measured. [87] The instruments have a validity that represent the results are measured comprehensively, effectively, and accurately according to indeed of measuring. [88] The major type of validity consists of content, construct, and criterion-related. [89]

Content validity

Content validity is defined as measure items in subdomain according to domain of the purpose of instrument. [87] For example, objective to identified a fear of falling questionnaire should be the questions identified suffered to activity daily living. To assess the content validity usually use a qualitative approach by an experts committee using the content validity index. [87] However, the content validity is scientifically weak because this is considered subjective. [89]

Construct validity

The construct validity is defined as variables or outcome represents really the construct of theoretical framework of measured. [88] The construct validity consists of convergent and discriminant validity.

Convergent validity is defined as comparing the correlations between two measures of construct that theoretically should be related. [89] For example, a correlation study between the TUG and TWT which are focus on walking performance test.

Discriminant validity is defined as a classify any variables in group of variables associated to measurement error or the theoretically construct of instruments are contrast. [90] For example, relationships between the Mini-BESTest and ABC which are focused on balance performance and fear of falling, [91] respectively.

Criterion-related validity

The criterion-related validity is defined as a measure how well one measure predicts an outcome for another measure. It is useful for predict of performance in another situation. The criterion-related validity consists of concurrent and predictive validity. [88]

Concurrent validity is defined as a measure how well one measure predicts an outcome for another measure at same time. [89] For example, correlations study between the BBS and BESTest showed strong correlations mean that patient who low performance assessed by the BBS can predict an outcome from assessed by the BESTest is also low performance.

Predictive validity is defined as a measure of how well a test predicts future abilities. It is important for helping screening risk in the future and prognosis. [92] For example, a score of measure below this point will be high risk of falling.

CHAPTER 3
RESEARCH METHODOLOGY

Research design

This study was an observational validity study. The correlation between participants' score on the S-BESTest with the clinical reference tools which were the CB&M and the BBS were tested to determine concurrent validity of S-BESTest in people with chronic stroke. Prior to the validity study, rater training and reliability test were done to ensure accuracy and consistency of the scores of the S-BESTest and the clinical reference tools. Video case-based test was used as procedure for the reliability testing.

Participants

Participants who have been diagnosed as unilateral hemispheric stroke, aged 18 years old and older, and had onset of stroke more than 6 months for reliability test and validity test in this study were recruited with the same inclusion and exclusion criteria. Individual persons with chronic stroke who meet study's criteria were invited to participate in this study.

- **Inclusion criteria**

Inclusion criteria was shown as follows;

1. able to perform walk independently with or without gait aid and orthosis at least 6 meters;

2. able to perform serial-3 subtraction from 90 at least 5 steps or able to perform verbal fluency of fruits category at least 5 fruits. [93]

- **Exclusion criteria**

All individuals who pass the inclusion criteria were excluded from the study if they had;

1. motor and/or sensory aphasia;

2. recurrent stroke and any neurological disorder other than stroke;

3. any other diseases or conditions that affect participant's safety during a session of data collection, e.g., unstable vital signs, chest pain with unstable angina, an

untreated trauma injury, and any others red flag signs e.g., fever, history of trauma or cancer, unexplained weight loss; [94]

4. pain that affect the ability to stand and walk or pain score (Numerical Rating Scales (NRS)) more than 5 score from 10 score [95] on the day of testing session;

5. or lack of ability to decisions on participate in this study by him/herself that score less than 5 score using the 5-questions to decision of being a volunteer in Thai language (Appendix A). [96]

- Withdrawal or termination criteria

1. Participants who had any other diseases, conditions, pain or pain score (NRS) more than 5 score from 10 score [95] that could not perform balance testing on the experimental day were terminate from this study.

2. Participant could immediately terminate in this study without reporting to researcher. Participant was received healthcare service such as home visit or treatment in hospital as usual.

- The sample size

The sample size for this study was calculated by following equation. The sample size for reliability and concurrent validity studies were calculated based on different value of correlation coefficient regarding information from related previous studies.

$$\eta = \left(\frac{Z_{\alpha} + Z_{\beta}}{Z_{(r)}}\right)^2 + 3$$

The sample size for the reliability testing, a sample size of ten was estimated from a power of 0.80 and an alpha level of 0.05. A null ICC of 0.60 and expected ICC of 0.94 were determined by a previous study. [27] Total participants for reliability study were 10 persons.

The sample size calculation for the validity study was based on a power of 0.80 and alpha level of 0.05. A correlation coefficient (r) of balance measure was 0.6 that represents adequate correlation. [97] A correlation coefficient for null hypothesis was 0.1 that represents poor correlation. [97] Sample sizes of 20 were the minimum number of participants required to identify a statistically significant correlation test for this study. To meet the target sample size, thirty-seven people with stroke were recruited. Seventeen persons were excluded from this study because they could not walk independently (3 persons), had motor aphasia (1 person), had recurrent stroke and other neurological conditions (3 persons), had pain at knee or lower back affecting the ability to stand and walk (3 persons), had hearing loss (1 person), and had personal issues that were not related to health problems (6 persons), such as personal business causing inconvenience to travel to participate the scheduled activities, unable to contact telephone number provided, and worried that participating the research at the hospital increase risk of the COVID-19 virus infection. Total participants for validity study were 20 persons.

Material and research tools

Measurement

Four research tools were used in this study. The Fugl-Meyer Assessment (FMA) was used to characterize motor function of participants. The CB&M, the BBS, and the S-BESTest were used to assess balance performance.

The FMA is a stroke-specific scale to determine impairment of neurological functions after stroke with five domain assessments, i.e., motor function, balance, sensation, joint range of motion, and pain. [98] Score from the FMA-Lower Extremity (FMA-LE), a subscale of the FMA can be interpreted separately. The FMA-LE consists of 16 tasks to assess movement of lower limb with performance. The score for each task from 0 to 2 points (no active motion to motion appears to be normal). The maximum score of the FMA-LE subscale is 34 points. [82] The high score on FMA-LE can indicate a higher level of mobility function in chronic stroke survivors. [81] Motor function of lower extremity is important factor of functional balance performance. [58, 82] Therefore, the FMA-LE was administered in this study in order to characterize participant's level of mobility function (Appendix B). This test required 15-20 minutes to administration.

The CB&M, a performance-based assessment scale (Appendix C). [19] It is a valid to assess balance in patients with chronic stroke who have moderate to high balance performance.[18] The CB&M consists of 19 tasks in advanced balance and mobility, e.g., walk, look and carry, descending stairs, and walking with looking.[19] The score for each task ranged from "0", cannot perform or is not attempt or perform with assistive device, to "5", perform fully. A total score of CB&M is 96 points.[19] This test required 20-30 minutes to administration.

The BBS is a reliable balance assessment tool (excellent intra-rater and inter-rater reliability with an ICCs = 0.95-0.98) and valid to assess functional balance in patients with stroke, especially for those who has moderate to severe motor impairment.[16] The BBS consists of 14 functional tasks of sitting and standing balance (Appendix C). The score for each task range from 0 to 4 points (cannot perform to perform fully) with a total possible score of 56 points.[80] It required 15-20 minutes for administration.[16]

The S-BESTest is a short version of BESTest, has been developed for using in patients with stroke.[27] It is reliable tools (ICCs = 0.88-0.98) and valid to assess systems balance impairments in subacute stage of stroke patients with low to high functional ability.[27] The S-BESTest consists of 13 tasks in standing and walking in real situation, e.g., TUG with dual task, change in gait speed, and walk with head turn (Appendix C). The score for each task ranged from "0", cannot perform, to "3", perform fully. One point is deducted when subject must use an assistive device. A total score of the S-BESTest is 39 points. It required 7-10 minutes for administration.[27]

Materials

The materials used in this study included the followings Table 4.

Table 4 Materials of this study

Measurement	Equipment	Picture
FMA-LE	1. Reflex hammer	 Figure 1 Reflex hammer

Table 4 (Continued)

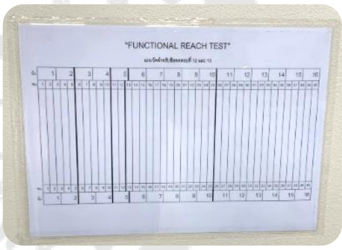
Measurement	Equipment	Picture
FMA-LE (Continued)	2. Bedside table	 Figure 2 Bedside table
S-BESTest	3. Ten degrees incline ramp	 Figure 3 Ten degrees incline ramp
	4. Measuring tape	 Figure 4 Measuring tape
	5. Five pounds of free weight	 Figure 5 Five pounds of free weight
	6. Airex ® foam (medium density, 16x20x2.5 inches x 2 pieces)	 Figure 6 Airex ® foam

Table 4 (Continued)

Measurement	Equipment	Picture
CB&M	7. Visual target	 Figure 7 Visual target
	8. Box	 Figure 8 Box
	9. Two and seven pounds of free weights	 Figure 9 Two and seven pounds of free weights
S-BESTest, BBS, and CB&M	10. Stair steps height 6 inches	 Figure 10 Stair steps
	11. Stopwatch	 Figure 11 Stopwatch

Table 4 (Continued)

Measurement	Equipment	Picture
Others	12. Marking tape	 Figure 12 Marking tape
	13. Standard chair	 Figure 13 Standard chair
	14. OMRON ® blood pressure monitor	 Figure 14 OMRON ® monitor
	15. Recording tools; iPhone 12 Pro Max and tripod	 Figure 15 Recording tools

Procedure

Rater training

A researcher (KS), a graduate physical therapy student and four-physical therapists were involved in the data collection of this study (raters). They were physical therapists who had experienced with stroke rehabilitation experience of at least 2 years without experience in using the balance assessment. All raters were participated in a four-steps training workshops prior to data collection of this study.

One assessment tool was assigned to each rater. There were four steps of the rater training. On the first step, all raters studied a document of assessment method, command, and scoring criteria of an assessment tool he or she responsible for participants' assessment including the FMA-LE (rater TD), CB&M (rater OI), BBS (rater OI), and S-BESTest (rater KS, rater PS, and rater PE). This step took within 2 days. The second step, all raters were asked to practice hand-on administration (approach and command instruction) the test with two healthy persons and one patient with stroke who volunteers for this session within 2 days. The third step, raters practiced scoring patients' performance based on each assessment tool using two video clips of patients' performance (permitted for educational and research purposes). Assessors were assigned to complete the video scoring process from two sets of the patients' videos within 2 days. In the fourth step, scores from raters were compared and a discrepancy discussed with two physical therapy lecturers (TW and NC) who had an experience of using those assessment tools with 2 sessions on 2 days. The total duration to complete the four steps of the rater training process was 8 days.

Reliability testing

After training workshop via video conference meetings, intra-rater and inter-rater reliability of three raters, including rater KS, rater PS, and rater PE, were evaluated to ensure accuracy and consistency of the total score and domain scores of the S-BESTest. Moreover, intra-rater reliability of each rater of total score of other balance assessment tools, i.e., the BBS, and the CB&M, were evaluated. Video clips of stroke patients' performance of the S-BESTest were conducted under a study with Hong Kong Polytechnic in 2018 by a research consultant (TW). Video clips of the BBS and the

CB&M conducted a study in community at Rangsit Sub-district, Thanyaburi District, Pathumthani Province, Thailand in 2016 by a research group (NC and BC). Permission and consent for educational and research purposes were received before using ten video clips of stroke patients' performance for the S-BESTest and another ten video clips for the BBS and CB&M. All video clips were shared with all raters on Google Drive. Each set of video clips contains multiple video clips of a participant that was filmed during his or her performance when being tested with assessment tools. The raters were asked to score immediately after the end of each item. A few minutes of braking periods were provided to the raters after finished watching and scoring each video clip. However, stopping or pausing a video clip during a performance test of any item was not allowed. Besides, the raters were not allowed to repeat the video clips to prevent bias for scoring the patients' performances. Discussion of scores or patients' performances were not allowed either. All raters were scored the patient's performance from the same set of the video clips on 2 separate occasions. The second occasion was performed 10 days after the first occasion to prevent recall bias. The scores of S-BESTest items were recorded in Google Form generated for each rater for the test that he or she was assigned. The raters were asked to submit the scores within 5 minutes after completely scoring the performance of each patient.

Research setting for the validity study

This study set at Muang Phitsanulok District, Phitsanulok Province, Thailand. Data collection was performed at six sub-district health promotion hospitals nearby participant's areas and Naresuan University Hospital, according to participants' convenience.

Recruiting participants for the validity study

Invitation information (i.e., study's objective and required characteristics of a tentative participant) was announced to patients with stroke by research assistance (hospital officers and village health volunteers). Convenience sampling method was used in this study.

Potential participants were screened with the study's criteria by rater KS. General characteristics and medical information of participants (age, gender, weight, height, Body Mass Index (BMI), times since stroke, type of stroke, and affected side) were directly interviewed from potential participants. In addition, patients record form of potential participants were reviewed by a vascular neurologist (Asst. Prof. Duangnapa Roongpiboonsopit, MD.) to ensure their eligibility and safety to participate in this study. Prior to potential participants were asked to sign a consent form, their ability to decide to participate on their own was ensured using 5-Questions to decision of being a volunteer in Thai language (Appendix A).

On the first session of assessment, the FMA-LE was administered to each participant by rater TD. This procedure was performed at six sub-district health promotion hospitals nearby participant's areas or Naresuan University Hospital and required 20 minutes to administration. Participants' general characteristics and clinical information were concealed to other raters. An appointment with each participant made for another balance assessment session within one week after the first session assessment.

Data collections for the validity study

Before validity testing, the researcher was measured to vital signs and asked to what an activity after first session, pain, and other diseases that affect participant's safety during a session of data collection to ensure stable medical status and without termination criteria.

People with chronic stroke who meet the study's criteria and willing to be a participant in this session were administered with the CB&M (rater OI), the BBS (rater OI), and the S-BESTest (rater KS). The evaluation was performed at six sub-district health promotion hospitals nearby participant's areas and Naresuan University Hospital. Total items of three balance tests contained 49, duplicated items of all balance test were grouped and measured once. After grouping of duplicated items, only 42 items of balance test were administered to participants (Appendix C). Duplicated items included standing with eyes closed and stand on one leg that commanded by rater KS and scoring of balance performance by each rater of responsible for participants' assessment. Score was further reduced if there was the use of walking aid, according to each balance assessment tools (Appendix C). The sequence of the balance test was set from sitting position to standing and walking. Time to balance test of each item about 1 minute. Each participant received one minute of resting after finishing every 2 items to avoid fatigue. All participants were assessed within 1 day. If they were unable to complete all balance tests within one day e.g., resting duration more than protocol or any reasons of participants, the remaining tests were administered within 7 days. If the balance test continued one the next day, the symptoms (e.g., high pain score, fatigue, and high blood pressure) that might affect participants' balance performance and safety were screened again to ensure the reliability of results. All participants received the same verbal instruction. Estimated time to complete the evaluation about 2 hours including the resting time. Performance was recorded for further verification.

Safety of all participants were ensured by a physical therapist who stood near the participants. In case of the adverse event such as, falls during testing or harmful symptoms (i.e., blood pressure higher to 180/110 mmHg or lower than 90/60 mmHg), a researcher would provide first aid to participants. If symptoms did not improve, participants would be received an appropriate treatment regarding their right in healthcare service under supervision of a vascular neurologist (Asst. Prof. Duangnapa Roongpiboonsopit, MD.). Moreover, a researcher KS would responsible for additional treatment costs caused by the adverse event.

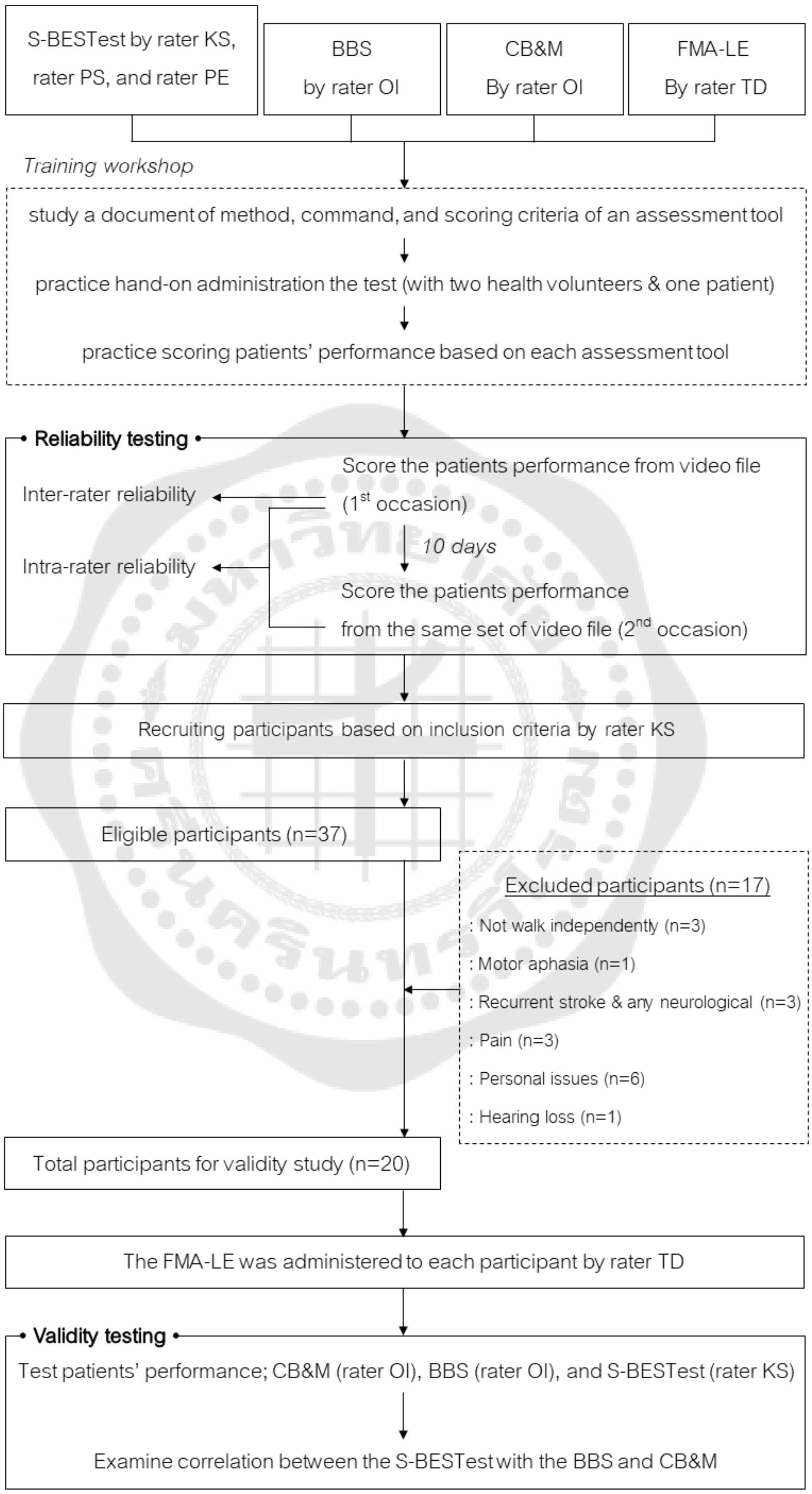


Figure 16 Procedure of this study

Data analysis

Descriptive statistical analysis was performed for demographic and baseline clinical characteristics people with chronic stroke for reliability study. The data with ratio scale, including age and time since stroke onset were presented in mean with standard deviation (SD) and range. The data with nominal scale, including gender, type of stroke, and affected side, were presented in frequency with percentage.

The intra-rater and inter-rater reliability were calculated using the intraclass correlation coefficient (ICC) model (3, 1) and model (2, 1), respectively. ICC value of 0.80 and above indicates excellent correlation (good reliability), while 0.80-0.60 indicates adequate correlation (moderate reliability), and 0.60-0.40 indicates poor correlation (weak reliability). [(99)]

Descriptive statistical analysis of demographic and baseline clinical characteristics people with chronic stroke for validity study. The data with ratio scale, including age, height, weight, BMI, time since stroke onset, and FMA-LE scores were presented in mean with SD and range. The data with nominal scale, including gender, type of stroke, and affected side, were presented in frequency with percentage.

Percentage frequency distributions of the S-BESTest, BBS, and CB&M were analyzed. The floor and ceiling effects of the S-BESTest, BBS, and CB&M were calculated as the percentage of minimum and maximum possible scores, respectively. Ceiling and floor effects of 20% or above were interpreted as significant. [(100)]

Total scores of the S-BESTest, the BBS, and the CB&M were presented in mean with SD. Shapiro–Wilk test was used to examine distribution of the data. Pearson's Product-Moment Correlation was used to examine correlation between participants' total score of the S-BESTest and the CB&M and the BBS in order to determine the concurrent validity property of the S-BESTest against the CB&M and the BBS.

Correlations between domains' score of the S-BESTest and total score of the CB&M and the BBS were also analyzed. This analysis was done to describe how the different components of the S-BESTest reflect balance compared to the BBS and the CB&M which measure different aspects of balance. The BBS focuses on anticipatory and stability limit in sitting and standing positions while the CB&M focuses on more challenged balance activities.

Strength of the correlation was be interpreted according to correlation coefficients of 0.00-0.49 was interpreted as poor, those of 0.50-0.79 as moderate, and those 0.80 or higher as excellent correlation. [101] Statistical significant was set at p-value <0.05. All analysis was conducted using the SPSS statistical software (SPSS version 25, ICN:793700).

Ethical considerations

The study protocol was approved by the institutional review board of Srinakharinwirot University (number SWUEC-G-205/2564E). Before participated in this study, all participants were asked to sign a consent form before taking part in the study.

This study respect for privacy and confidentiality. The recording was used code number instead of the participant 's name and all participant 's data including electronic files, images, clip video, and audio were saved on personal computer with password that only a researcher KS known. All participant 's data retained for 5 years after the end of this study by researcher KS who responsible for confidentiality of participants that explain in information sheet.

Research funding

This study was currented apply research funding from the Faculty of Physical therapy, Srinakharinwirot University (number 218/2564). Additionally, the Faculty of Graduate school, Srinakharinwirot University was offered tuition scholarships.

CHAPTER 4
FINDINGS

Reliability of the S-BESTest

Characteristics of patients in the reliability test

Video clips of the S-BESTest assessment used in this study were recorded from a total of 10 people with chronic stroke. They were both male and female (7 and 3 persons, respectively) aged between 53 to 72 years old and had a wide range of time post-stroke (35 to 155 months). Average age and time since stroke onset and other clinical characteristics are shown in Table 5.

Table 5 Demographic and clinical characteristics of people with chronic stroke in the reliability test

Characteristics (n=10)	Mean ± SD	Range
Age (years)	63.90 ± 6.57	53-72
Gender (male/female), n (%)	7/3 (70/30)	-
Time since stroke onset (months)	103.94 ± 38.30	35-155.50
Type of stroke (ischemic/hemorrhage), n (%)	7/3 (70/30)	-
Affected side (right/left), n (%)	4/6 (40/60)	-

Reliability of total score of the S-BESTest

The intra-rater reliability of the S-BESTest total score of all raters was excellent with ICC $_{(3, 1)}$ ranging from 0.96 to 0.99 (95% CI = 0.85-0.99, p-value <0.01) (Figure 17 A, B, and C). The inter-rater reliability of the S-BESTest total score was excellent with ICC (2, 1) of 0.97 (95% CI = 0.93-0.99, p-value <0.01) (Figure 17 D).

Reliability of domain scores of the S-BESTest

The intra-rater reliability of the domain scores was excellent with ICCs $_{(3, 1)}$ 0.93-1.00 (95% CI = 0.71-1.00, p-value <0.01) (Table 6). Likewise, the inter-rater reliability of the domain scores of the S-BESTest was excellent with ICCs $_{(2, 1)}$ 0.91-0.98 (95% CI = 0.76 -0.99, p-value <0.01) (Table 7).

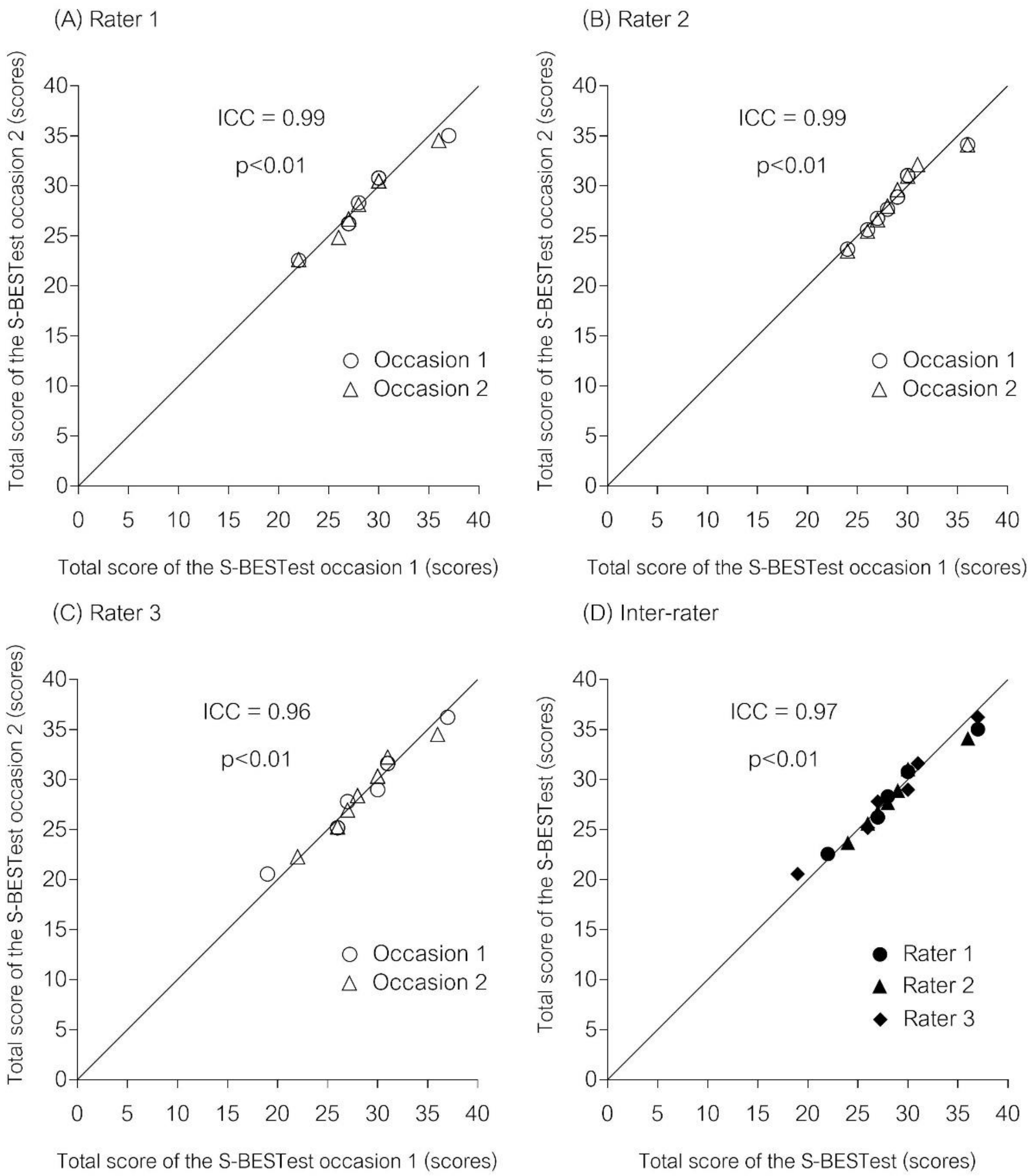


Figure 17 Intra-rater and inter-rater reliability of total score of the S-BESTest in people with chronic stroke (A) intra-rater reliability assessed by rater 1, (B) intra-rater reliability assessed by rater 2, (C) intra-rater reliability assessed by rater 3, and (D) inter-rater reliability between three raters, S-BESTest: Stroke-Balance Evaluation System Test, ICC: intraclass correlation coefficient

Table 6 Intra-rater reliability of domain scores of the S-BESTest in people with chronic stroke

Domain of the S-BESTest	Intra-rater reliability (n=10)		
	Rater 1	Rater 2	Rater 3
	ICC $_{(3,1)}$ (95% CI)	ICC $_{(3,1)}$ (95% CI)	ICC $_{(3,1)}$ (95% CI)
I Biomechanical constraints	0.98 (0.90-0.99)	0.93 (0.71-0.98)	0.96 (0.84-0.99)
II Stability limits	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
III Anticipatory adjustment	0.99 (0.97-0.99)	0.99 (0.94-0.99)	0.93 (0.73-0.98)
IV Reactive postural response	1.00 (1.00-1.00)	0.98 (0.93-0.99)	1.00 (1.00-1.00)
V Sensory orientation	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)
VI Stability in gait	0.95 (0.79-0.99)	0.93 (0.72-0.98)	0.93 (0.72-0.98)

All intraclass correlation coefficients (ICCs) were significant, with a p-value of <0.01.

CI: confidence interval

Table 7 Inter-rater reliability of domain scores of the S-BESTest in people with chronic stroke

Domain of the S-BESTest	Inter-rater reliability (n=10)	
	ICC $_{(2,1)}$	95% CI
I Biomechanical constraints	0.98	0.95-0.99
II Stability limits	0.91	0.76-0.98
III Anticipatory adjustment	0.97	0.90-0.99
IV Reactive postural response	0.94	0.82-0.98
V Sensory orientation	0.91	0.76-0.98
VI Stability in gait	0.97	0.92-0.99

All intraclass correlation coefficients (ICCs) were significant, with a p-value of <0.01.

CI: confidence interval

Reliability of the clinical reference tools

Intra-rater reliability of the BBS was excellent with ICC $_{(3, 1)}$ 0.99 (95% CI = 0.96-0.99, p-value <0.01). Likewise, the intra-rater reliability of the CB&M was excellent with ICC $_{(3, 1)}$ 0.99 (95% CI = 0.99-1.00, p-value <0.01).

Validity of the S-BESTest

Participants

Twenty persons with chronic stroke who met the study's criteria were participated in this study. All participants were able to complete all balance tests within one day. Each participant was evaluated for approximately 2.5 hours.

Participants with right or left hemiplegia were mostly diagnosed with ischemic stroke that had high functional performance (i.e., ambulation without gait aid nearly to normal gait pattern, mild neurological deficit, and performed basic activity daily living by him/herself independently) as evidenced by score of the FMA-LE. Participants were from outpatient department that came for follow up visit after stroke onset at 6-12 months by vascular neurologist without receiving physical therapy rehabilitation. Demographic and clinical characteristics of people with chronic stroke shown in Table 8.

Table 8 Demographic and clinical characteristics of people with chronic stroke in the validity test

Characteristics (n=20)	Mean ± SD	Range
Age (years)	61.50 ± 9.99	40-77
Height (cm)	159.15 ± 10.09	138-180
Weight (kg)	64.70 ± 10.52	45-84
BMI (kg/m^2)	25.60 ± 4.25	19.81-37.33
Gender, (male/female), n (%)	10/10 (50/50)	-
Time since stroke onset (months)	22.05 ± 24.68	7-110
Type of stroke (ischemic/hemorrhage), n (%)	17/3 (85/15)	-

Table 8 (Continued)

Characteristics (n=20)	Mean ± SD	Range
Affected side (right/left), n (%)	9/11 (45/55)	-
FMA-LE (/34 scores)	23.85 ± 8.16	6-33
BBS (/56 scores)	45.85 ± 12.48	10-56
CB&M (/96 scores)	36.60 ± 18.80	1-67
S-BESTest (/39 scores)	24.75 ± 8.49	4-36

Note: BMI = Body Mass Index; FMA-LE = Fugl-Mayer assessment-Lower Extremity subscale; BBS = Berg Balance Scale; CB&M = Community Balance and Mobility Scale; S-BESTest = Stroke-Balance Evaluation Systems test; cm = centimeters; kg = kilograms; kg/m^2 = kilograms per square meters

Distribution of scores on the balance test

Figure 18 shows distribution scores of the total on the S-BESTest, BBS, and CB&M in participants with chronic stroke. It can be seen from this figure that none of the participants received a zero score and maximum score on the S-BESTest. On the contrary, some of the participants had maximum scores (56 scores) on the BBS. Calculation of percentage of scores in their frequency distribution showed 10 percent of participants reached the maximum score on the BBS, indicating the potential ceiling effect of this tool in patients with chronic stroke. Although, no patients received minimum score (0 score) on the CB&M, fifteen percent of the participants had very low score (a one to two scores) on this tool. These findings suggested the possible ceiling effect of the BBS and floor effect of the CB&M.

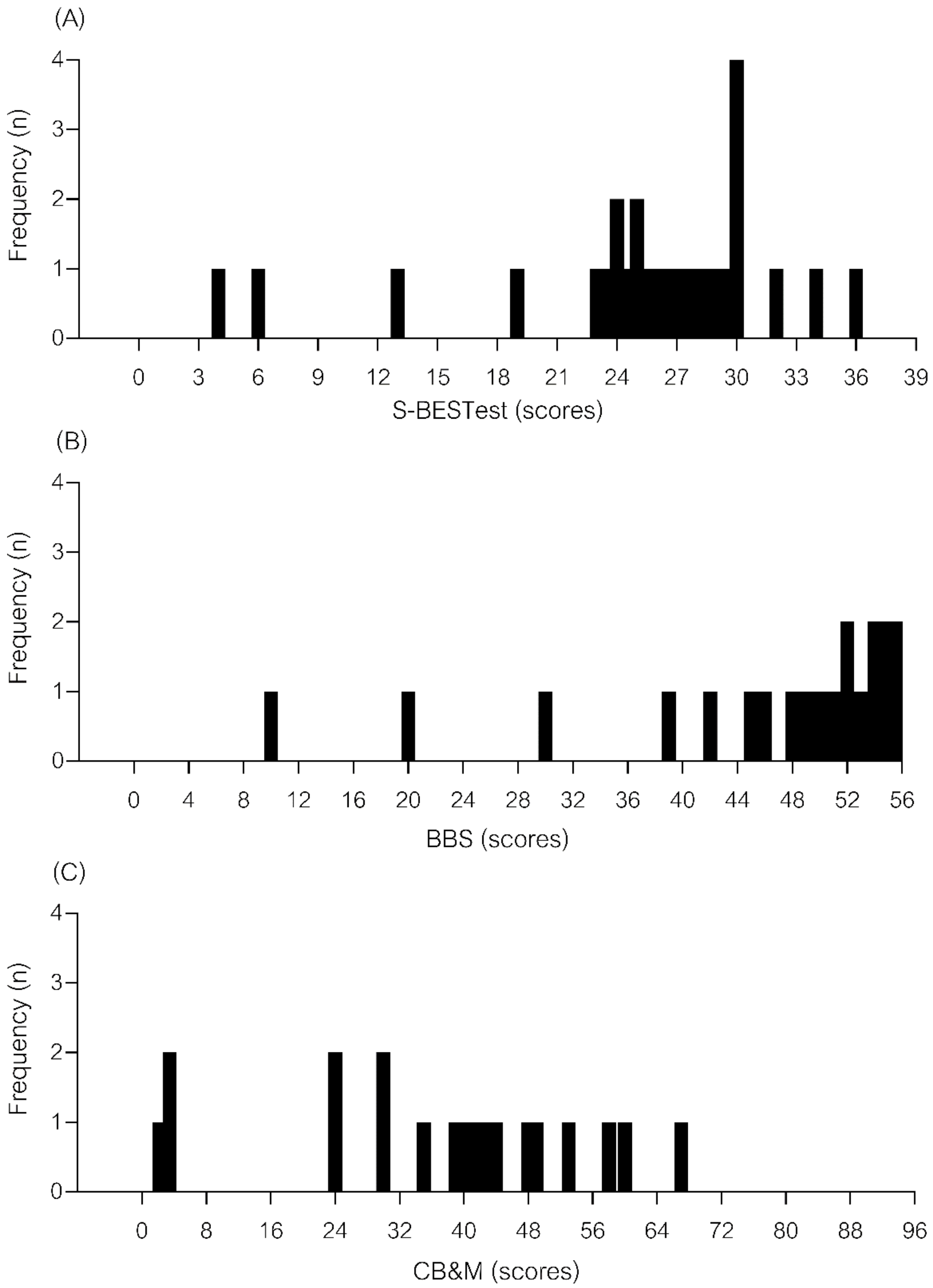


Figure 18 Frequency of distribution score

; (A) Stroke-Balance Evaluation Systems Test (S-BESTest), (B) Berg Balance Scale (BBS), and (C) Community Balance & Mobility Scale (CB&M) are shown. Data of 20 participants with chronic stroke are shown

Validity of the S-BESTest

Correlations between the total scores of the S-BESTest with the BBS and CB&M were shown in Figure 19. Total score of the S-BESTest and BBS was significantly correlated ($r = 0.93$, $p<0.01$), indicating concurrent validity of total score of the S-BESTest in patients with chronic stroke. Likewise, the total score between the S-BESTest and CB&M ($r = 0.86$, $p<0.01$) showed excellent correlations in patients with chronic stroke.

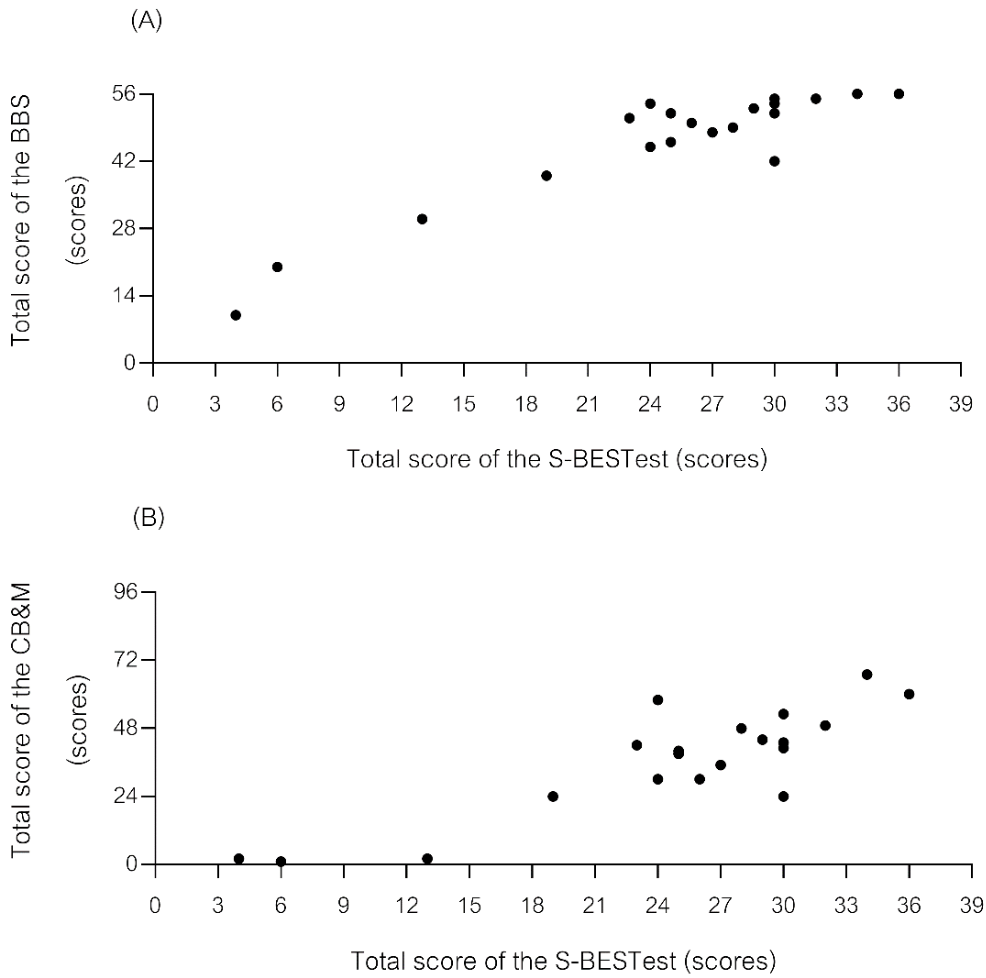


Figure 19 The scatter diagram shows a correlation between scores of the balance test ; between total score of the Stroke-Balance Evaluation Systems Test (S-BESTest) with scores on total score of the Berg Balance Scale (BBS) (A) and Community Balance and Mobility Scale (CB&M) (B). Each point on the scatter diagram represents data from an individual participant

Correlations between the domain scores of the S-BESTest with the BBS and CB&M are shown in Table 9. The sensory orientations and stability in gait domain scores of the S-BESTest showed excellent correlations with the BBS (r = 0.91 and 0.93, respectively at p<0.01). Additionally, the anticipatory postural adjustment and stability in gait domain scores of the S-BESTest were excellent in correlating with the CB&M (r = 0.82 and 0.86, respectively at p<0.01).

Table 9 Correlations of domain scores of the S-BESTest in people with chronic stroke with the BBS and CB&M

Domain of the S-BESTest		BBS (n=20)		CB&M (n=20)	
		r	p-value	r	p-value
Domain I	Biomechanical constraints	0.47	0.04	0.39	0.09
Domain II	Stability limits	0.77	<0.01	0.62	0.01
Domain III	Anticipatory postural adjustment	0.75	<0.01	0.82	<0.01
Domain IV	Reactive postural response	0.50	0.03	0.47	0.04
Domain V	Sensory orientation	0.91	<0.01	0.77	<0.01
Domain VI	Stability in gait	0.93	<0.01	0.86	<0.01

Note: BBS = Berg Balance Scale; CB&M = Community Balance and Mobility Scale; S-BESTest = Stroke-Balance Evaluation Systems test; significant correlation was set at p-value < 0.05

CHAPTER 5
DISCUSSION AND CONCLUSION

Discussion

This study aimed to examine whether the S-BESTest is a valid measure for determining balance performance similar to the BBS and the CB&M in people with chronic stroke. Rater training was successful and the reliability of the balance assessment tools was ensured. The reliability and the validity of the S-BESTest are discussed below.

The findings of excellent intra-rater and inter-rater reliability of the S-BESTest and intra-rater reliability of the clinical reference tools are as expected. The intra-rater reliability of the S-BESTest reflected that the raters' judgment between the first and second occasions was consistent. Results on the excellent inter-rater reliability of the total score of the S-BESTest reflected that there were a few variations of the patients' performance that were scored by three different raters. These results are probably due to clear instructions on how to rate the patients' performance and the raters' training process. Comparing with another study of the S-BESTest, degrees of the reliability of the total score and domain scores of the S-BESTest reported in this study (ICCs = 0.91-1.00) were corresponded to a previous study in patients with subacute stroke (ICCs = 0.88- 0.98). [27] The raters' training process and scoring the patients' performance from videos could be a reason for similar results between the present and the previous study. [27] These results confirmed that the S-BESTest could provide reliable test results when used to assess postural control problems in any recovery stage of patients with hemiplegic stroke.

In this study, the overall inter-rater reliability of the domain scores of the S-BESTest was excellent with ICCs of 0.91-0.97, which were higher than ICCs of 0.88-0.96 reported in the previous study. [27] During the raters' training, two discussion sessions about how to score each item of the S-BESTest were done before and after the practice of scoring the patient's performance in a video demonstration. This process could help the raters to understand the scoring criteria of the S-BESTest with the same context better than practice scoring performance of a healthy person as done in a previous study. [27] It could be a reason for the higher intra-rater reliability of the domains' score of the S-BESTest among this study and a previous study in patients with subacute stroke. [27]

Regarding the lower border of 95% CI the intra-rater reliability of domain scores of the S-BESTest, this study founded that the stability in the gait showed the lowest value of the reliability (95% CI of ICCs = 0.72-0.79) when compared with the other domains (95% CI of ICCs = 0.71-1.00). This result was in line with the finding of a previous study in patients with subacute stroke that the stability in the gait domain had the lowest intra-rater reliability (95% CI of ICCs = 0.92-0.99). [27] Some errors found in the stability in the gait domain indicated that the raters prescribed different scores for the same patients when repeating the measurement. Since the patients' gait performances were rated from the same set of video clips, changes in the performance of the patients were not a reason for such inconsistency. It could be from the limitation of the scoring from the video where the points to start and stop the timing of walking were not as clear as in the field testing. Also, the lower border of 95% CI the inter-rater reliability of sensory orientation domain score of the S-BESTest showed an adequate correlation of the reliability (lower border 95% CI of ICC = 0.76), however, it was lower than the reliability of the scores from other domains such as stability in gait (lower border of 95% CI of ICCs = 0.82-0.95). The result study was similar to the findings from a previous study (lower border 95% CI of ICC = 0.82) in the patients with subacute stroke which showed that the sensory orientation domain had lower reliability compared to lower border of 95% CI of ICC of stability in gait domain (lower border of 95% CI of ICC = 0.83). [27] Determining the patients' performance of sensory orientation included time of standing with or without postural sway in the front view of the patients' performance in the video clips. The camera angle was important to decide postural sway while standing on various surfaces. Thus, the raters should score the patients' performance along with the lateral view of the video clips. Besides, the authors recommended the use of a measuring tape with a highly visible and accurate distance line to reduce an error of the rater's judgment about the distance the patient can reach.

The reliability of the raters is the first requirement before the use of standardized scales in clinical practice. This study established that the rater's training can help improve the rater's reliability. The method of rater training where clinicians can apply to their clinical settings is also suggested in this study. Although sequence of ten sets video clips using in the two occasions of reliability testing was not random, the risk of recall bias was prevented with 10 separation days between the two occasion of video scoring. However, the use of the random sequence to prevent recall bias may consider used in a study that cannot set the long duration for the separation period between the two occasions of the scoring sessions and cannot finish scoring video for each patient within one day.

Significance of this finding of excellent intra-rater reliability of the S-BESTest and the clinical reference tools were ensured the raters of this study are reliable.

Strong correlations between the total score of the S-BESTest and the scores from the clinical reference which were the BBS (r = 0.93) and the CB&M (r = 0.86), in this study indicate concurrent validity of the S-BESTest. This findings corresponds to the previous studies, showing high correlation between scores on the S-BESTest and the BBS in patients with subacute stroke (r = 0.95). [27] All of the above findings were consistent, suggesting that the S-BESTest was valid to reflect the balance problems in people with stroke at all stages of recovery, both subacute [27] and chronic.

In addition, the result of this study was similar to those from previous studies that reported the properties of the system-based balance assessments. [22, 28, 29] High correlation between total score of the original BESTest (r = 0.78), the Mini-BESTest (r = 0.83), and the Brief-BESTest (r = 0.87) and the BBS were reported in previous studies of patients with chronic stroke. [22, 28, 29] This similarity can be explained by the multicomponent measure of balance control and a similar scoring system, as well as characteristics of patients participated in those studies including average age (this study = 61.50 years; previous studies = 57.1-61.1 years), [22, 28, 29] time since stroke (this study = 22.5 months; previous studies = 34-108 months), [22, 28, 29] lower extremity function of the affected side (FMA-LE score in this study = 23.8; a previous study = 19), [29] and balance performance (BBS score in this study = 45.6; previous studies = 48.6-54). [22, 28, 29]

Total score of the S-BESTest was highly correlated with total score of BBS because both tools assess similar construct of balance control in term of static and dynamic balance tasks. Some of the measurement items from the S-BESTest and BBS are also the same with different scoring criteria, including standing with eyes closed and standing on non-paretic leg. Likewise, the correlation of the total score of the S-BESTest and total score of the CB&M is possible because both tools address the challenging balance task that are essential for living in community safely, without falls. For example, standing on one leg (S-BESTest and CB&M), walking with look at visual target, walk with look at visual target and carry object (CB&M), and TUG-dual task (S-BESTest). Considering level of correlation, the S-BESTest was found to be correlated with the CB&M at a lower level than the BBS, possibly because the testing item in the CB&M is more challenging than the items in the S-BESTest such as hopping forward on one leg, lateral scooting on one leg, and running with control stop.

Results on an excellent correlation between some of domain scores of the S-BESTest with total score of the BBS and CB&M (r = 0.82-0.93) indicated that each domain of the BESTest measured the same construct as those in the BBS and CB&M. These findings suggested that, the anticipatory postural adjustment and stability in gait domain of the S-BESTest had a potential to predict the score of the CB&M which will have benefit in predicting the level of functional balance performance in community. However, this suggestion needs to evaluate further in the future study.

This study showed that the S-BESTest had no floor and ceiling effects corresponding to a previous study. [27] The magnitude of floor effect of the S-BESTest in a previous study was higher than of this study (18.6%) may be due to differences in subjects' characteristics. [27] Previous study evaluated patients with subacute stroke who had low to high level of functional ability (FMA-LE score ranges from 2-34 out of 34, mean ± SD = 19.39 ± 10.06) [27] but the majority of participants in this study had high functional performance (FMA-LE score ranges from 6-33 out of 34, mean ± SD = 23.85 ± 8.16). Moreover, the high level of lower extremity function could be a reason of high percentage (10%) of participants with a maximum score on the BBS. The possibility of ceiling effect of the BBS found in this study is in line with previous studies that reported a ceiling effect of the BBS among patients with chronic stroke at 28.8 to 47.7%. [17, 18, 28] Similarity, possible floor effect of the CB&M in this study is in line with a previous study (6.8%) in people with chronic stroke. High functional performance is a possible reason of no floor effect of the CB&M found in the present study. All results indicate that the S-BESTest has the potential to identify balance problems in people with chronic stroke with varying balance performance. However, The S-BESTest in people with chronic stroke with low functional performance should be evaluated in further study.

Validity of the S-BESTest with the BBS and the CB&M was confirmed in the present study. This result suggests the usefulness of the S-BESTest in assessing balance problems in patients with chronic stroke. However, our study was carried out only on the concurrent validity. Application to detect clinically important changes over time has not been validated. This study included only people with chronic stroke who were able to walk independently for at least 6 meters. Further study should determine validities of the S-BESTest in assessing balance in people with chronic stroke who have low functional performance such as dependent or supervised walking. Applying the S-BESTEst in another setting should follow the training method suggested in this study to ensure the reliability of the raters and test results.

Conclusion

The S-BESTest had excellent intra-rater and inter-rater reliability in people with chronic stroke. Clear instructions on how to score and training sessions with an experienced physical therapist before using the scale are necessary for achieving excellent rater reliability of the S-BESTest. In addition, the S-BESTest had excellent concurrent validity with the BBS and CB&M. This test also demonstrated no floor and ceiling effects to identify of balance impairments in people with chronic stroke.

Therefore, the S-BESTest is the assessment tool suitable for determining balance problems in patients with chronic stroke.

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APPENDICES

APPENDIX A

APPENDIX A
INFORMATION OF PARTICIPANTS FORM

Date (screening): ....

Date (balance test): ....

No. of participant: ....

Personal data

Tel. ....

Address ....

Location of testing ....

General characteristics and medical information of participants

Age	..............years	Height .... m.	Weight ....Kg
Gender	☐ Male	☐ Female	BMI ....Kg/m.^{2}
Times since stroke	....	Months	**Vital signs**
Type of stroke	☐ Ischemic	☐ Hemorrhage	Blood pressure:
Affected side	☐ Right	☐ Left	............./............mmHg
Cognitive task	☐ Subtraction	☐ Fruits category	Heart rate:
Gait performance	....		..........................bpm

Note (gait aid, orthosis, pain, past history, medication, or underlying)

(Screening date): ....

(Balance test date): ....

Score of assessment

Tools	FMA-LE	S-BESTest	CB&M	BBS
Date	....	....	....	....
Score	....	....	....	....
	/34 points	/39 points	/96 points	/56 points

5-Questions to decision of being a volunteer in Thai language

คำถาม	คำตอบที่ยอมรับได้
1. ความเสี่ยงที่อาจเกิดขึ้นในการเข้าร่วมการศึกษา มีอะไรบ้าง (ตอบ 2 ข้อ)	- เมื่อยล้า - เวียนศีรษะ - ปวดบริเวณข้อ - ล้มขณะทดสอบ
2. ระบุสิ่งที่ท่านต้องปฏิบัติในระหว่างการศึกษาครั้งนี้	- ประเมินความสามารถด้านการรับรู้ - ประเมินความสามารถในการควบคุมการเคลื่อนไหวขา - ประเมินการทรงตัวในท่าต่าง ๆ เช่น ท่านั่ง ยืน เดิน เดินพร้อมกับหันศีรษะ และขึ้น-ลงบันได
3. กรณีที่ท่านไม่ต้องการจะร่วมโครงการวิจัยต่อไปอีก ท่านจะทำอย่างไร	- มีสิทธิ์ถอนตัวออกจากโครงการวิจัยเมื่อใดก็ได้ โดยไม่ต้องแจ้งให้ทราบล่วงหน้า
4. ขณะที่เข้าร่วมการศึกษานี้ แล้วท่านรู้สึกไม่สบายใจ หรือกังวล ท่านจะปฏิบัติหรือแจ้งผู้วิจัยอย่างไร	- สามารถติดต่อ นางสาวกนกพิชญ์ สัตยประกอบ ได้ที่เบอร์โทร 08-2394-9544
5. ท่านได้เข้ามาร่วมในโครงการวิจัยนี้ได้อย่างไร/วิธีไหน	- ถูกสุ่มมาเข้าร่วมโครงการวิจัย - สอดคล้องกับเกณฑ์คัดเข้า (เป็นผู้ป่วยอัมพาตครึ่งซีกเดินได้เอง ลบเลขหรือบอกชื่อผลไม้ได้)

สรุปผลการประเมิน

ในความเห็นของผู้วิจัย อาสาสมัครมีระดับการรู้สติปกติ สามารถสื่อสารได้ และตอบคำถามที่ยอมรับได้

ผู้วิจัย .... วันที่ ....

หมายเหตุ: หลังจากผู้ป่วยอัมพาตครึ่งซีก ได้รับการอธิบายเนื้อหาตามที่แสดงในเอกสารชี้แจงอาสาสมัครแล้ว ผู้วิจัยจะสอบถามอาสาสมัครด้วยชุดคำถาม 5 ข้อ ให้อาสาสมัครตอบ และเปรียบเทียบคำตอบที่ได้กับคำตอบที่ยอมรับได้ ผู้ป่วยจะต้องตอบคำถามถูกทุกข้อ ผู้วิจัยจึงจะขอให้ผู้ป่วยเซ็นชื่อในเอกสารยินยอมเข้าร่วมการวิจัย

อ้างอิงจาก Resnick B, et al. Reliability and validity of the evaluation to sign consent measure. The Gerontologist. 2007 Feb; 47(1): 69-77.

APPENDIX B

APPENDIX B

FUGL-MEYER ASSESSMENT-LOWER EXTREMITY (FMA-LE) FORM

Test	Item	Score
I. Reflex activity	Achilles	☐ 0 - No reflex activity can be elicited
	Patellar	☐ 2 - Reflex activity can be elicited
IIA. Flexor Synergy (in supine)	Hip flexion	☐ 0 - Cannot be performed at all
		☐ 1 - Partial motion
		☐ 2 - Full motion
	Knee flexion	☐ 0 - Cannot be performed at all
		☐ 1 - Partial motion
		☐ 2 - Full motion
	Ankle dorsiflexion	☐ 0 - Cannot be performed at all
		☐ 1 - Partial motion
		☐ 2 - Full motion
IIB. Extensor Synergy (in side lying)	Hip extension	☐ 0 - Cannot be performed at all
		☐ 1 - Partial motion
		☐ 2 - Full motion
	Hip adduction	☐ 0 - Cannot be performed at all
		☐ 1 - Partial motion
		☐ 2 - Full motion
	Knee extension	☐ 0 - Cannot be performed at all
		☐ 1 - Partial motion
		☐ 2 - Full motion
	Ankle plantar flexion	☐ 0 - Cannot be performed at all
		☐ 1 - Partial motion
		☐ 2 - Full motion
III. Movement combining synergies	Knee flexion beyond 90°	☐ 0 - No active motion
		☐ 1 - From slightly extended position, knee can be flexed, but not beyond 90°
		☐ 2 - Knee flexion beyond 90°

Fugl-Meyer Assessment-Lower extremity (FMA-LE) form (Continued)

Test	Item	Score
III. Movement combining synergies (Cont.)	Ankle dorsiflexion	☐ 0 - No active motion ☐ 1 - Limited dorsiflexion ☐ 2 - Complete dorsiflexion
IV. Movement out of synergy (Standing, hip at 0°)	Knee flexion	☐ 0 - Knee cannot flex without hip flexion ☐ 1 - Knee begins flexion without hip flexion, but does not reach to 90°, or hip flexes during motion ☐ 2 - Full motion as described
	Ankle dorsiflexion	☐ 0 - No active motion ☐ 1 - Limited dorsiflexion ☐ 2 - Complete dorsiflexion
V. Normal Reflexes (sitting)	Knee flexors, Patellar, Achilles	☐ 0 - At least 2 of the 3 phasic reflexes are markedly hyperactive ☐ 1 - One reflex is markedly hyperactive, or at least 2 reflexes are lively ☐ 2 - No more than one reflex is lively and none are hyperactive
VI. Coordination/ speed Sitting: Heel to opposite knee repetitions in rapid succession.	Tremor	☐ 0 - Marked tremor ☐ 1 - Slight tremor ☐ 2 - No tremor
	Dysmetria	☐ 0 - Pronounced or unsystematic dysmetria ☐ 1 - Slight or systematic dysmetria ☐ 2 - No dysmetria
	Speed	☐ 0 - Activity is more than 6s longer than unaffected leg ☐ 1 - 2-5.9s longer than unaffected leg ☐ 2 - Less than 2s difference
	Total score of FMA-LE	................................/ 34 points

APPENDIX C

APPENDIX C
THE THREE-BALANCE ASSESSMENT FORM

INSTRUCTION OF THREE-BALANCE ASSESSMENT

1. The sequence of the balance test were from sitting position to standing and walking which from item number 1 to 42.

2. Each participant received one minute of resting after finishing every 2 items to avoid fatigue.

3. Score patients' performance according to the scoring criteria of each item of each assessment. *

* REMARK

For the S-BESTest

: An item score decreases one point when subject must use an assistive device.

: An item score decreases zero point when subject needs physical assistance to execute an item score.

For the CB&M

: An item score decreases zero point when subject must use an assistive device.

The three-balance assessment form

No.	Item	Test	Score
1	Sitting without support (with the feet touching the floor)	BBS 3	☐ 4 - able to sit safely and securely for 2 min ☐ 3 - able to sit 2 min under supervision ☐ 2 - able to able to sit 30s ☐ 1 - able to sit 10s ☐ 0 - unable to sit without support 10s
2	Transfers from a bed to a chair	BBS 5	☐ 4 - able to transfer safely with minor use of hands ☐ 3 - able to transfer safely definite need of hands ☐ 2 - able to transfer with verbal cuing and/or supervision ☐ 1 - needs one person to assist ☐ 0 - needs two people to assist or supervise to be safe
3	Sitting to standing up	BBS 1	☐ 4 - able to stand without using hands and stabilize independently ☐ 3 - able to stand independently using hands ☐ 2 - able to stand using hands after several tries ☐ 1 - needs minimal aid to stand or stabilize ☐ 0 - needs moderate or maximal assist to stand
4	Standing without support (feet position free, no other constraint < 30s	BBS 2	☐ 4 - able to stand safely for 2 min ☐ 3 - able to stand 2 minwith supervision ☐ 2 - able to stand 30s unsupported ☐ 1 - needs several tries to stand 30s unsupported ☐ 0 - unable to stand 30s unsupported
5	Hip/trunk lateral strength	S-BESTest 1	☐ 3 - abducts both hips to lift the foot off the floor for 10s while keeping trunk vertical ☐ 2 - abducts both hips to lift the foot off the floor for 10s but without keeping trunk vertical ☐ 1 - abducts only one hip off the floor for 10s with vertical trunk ☐ 0 - cannot abduct either hip to lift a foot off the floor for 10s with trunk vertical or without

The three-balance assessment form (Continued)

No.	Item	Test	Score
6	Standing to sitting	BBS 4	☐ 4 - sit safely with minimal use of hand ☐ 3 - controls decent by using hands ☐ 2 - use back of legs against chair to control descent ☐ 1 - sits independently but has uncontrolled descent ☐ 0 - needs assist to sit
7	Standing with eyes closed < 30s	BBS 6	☐ 4 - able to stand 10s safely ☐ 3 - able to stand 10s with supervision ☐ 2 - able to stand 3s ☐ 1 - unable to keep eyes closed 3s but stays safely ☐ 0 - needs help to keep from falling
		S-BESTest 8	☐ 3 - 30s stable ☐ 2 - 30s unstable ☐ 1 - < 30s ☐ 0 - unable
8	Standing with feet together	BBS 7	☐ 4 - able to place feet together independently and stand 1 min safely ☐ 3 - able to place feet together independently and stand 1 min with supervision ☐ 2 - able to place feet together independently but unable to hold for 30s ☐ 1 - needs help to attain position but able to stand 15s feet together ☐ 0 - needs help to attain position and unable to hold 15s
9	Standing with Eye opened on foam surface	S-BESTest 9	☐ 3 - 30s stable ☐ 2 - 30s unstable ☐ 1 - < 30s ☐ 0 - unable
10	Incline with eyes closed	S-BESTest 10	☐ 3 - stands independently, steady without excessive sway, holds 30s, and aligns with gravity ☐ 2 - stands independently 30s with greater sway than in item 19B -OR-aligns with surface

The three-balance assessment form (Continued)

No.	Item	Test	Score
10	Incline with eyes closed (Continued)	S-BESTest 10	☐ 1 - requires touch assist -OR-stands without assist for 10-20s ☐ 0 - unable to stand >10s -OR-will not attempt independent stance
11	Reaching forward with outstretched arm	BBS 8	☐ 4 - can reach forward confidently 25 cm (10 inches) ☐ 3 - can reach forward 12 cm (5 inches) ☐ 2 - can reach forward 5 cm (2 inches) ☐ 1 - reaches forward but needs supervision ☐ 0 - loses balance while trying/requires external support
12	Functional reach lateral of non-paretic side	S-BESTest 2	☐ 3 - maximum to limit: > 25.5 cm (10 in) ☐ 2 - moderate: 10-25.5 cm (4-10 in) ☐ 1 - poor: < 10 cm (4 in) ☐ 0 - no measurable lean, or must be caught
13	Rise to toes	S-BESTest 3	☐ 3 - normal: stable for 3s with good height ☐ 2 - heels up, but not full range (smaller than when holding hands so no balance requirement) -or- slight instability & holds for 3s ☐ 1 - holds for less than 3s ☐ 0 - unable
14	Standing arm raise	S-BESTest 6	☐ 3 - Normal: Remains stable ☐ 2 - Visible sway ☐ 1 - Steps to regain equilibrium/ unable to move quickly w/o losing balance ☐ 0 - Unable, or needs assistance for stability
15	Compensatory stepping correction- lateral: paretic	S-BESTest 7	☐ 3 - Recovers independently with 1 step of normal length/width (crossover or lateral is okay) ☐ 2 - Several steps used, but recovers independently ☐ 1 - Steps, but needs to be assisted to prevent a fall ☐ 0 - Falls, or cannot step

The three-balance assessment form (Continued)

No.	Item	Test	Score
16	Standing, picking up a pencil from the floor	BBS 9	☐ 4 - able to pick up slipper safely and easily ☐ 3 - able to pick up slipper but needs supervision ☐ 2 - unable to pick up but reaches 2-5 cm (1-2 inches) from slipper and keeps balance independently ☐ 1 - unable to pick up and needs supervision while trying ☐ 0 - unable to try/needs assist to keep from losing balance or falling
17	Turning to look behind	BBS 10	☐ 4 - looks behind from both sides and weight shifts well ☐ 3 - looks behind one side only other side shows less weight shift ☐ 2 - turns sideways only but maintains balance ☐ 1 - needs supervision when turning ☐ 0 - needs assist to keep from losing balance or falling
18	Turning 360 degrees	BBS 11	☐ 4 - able to turn 360 degrees safely in 4s or less ☐ 3 - able to turn 360 degrees safely one side only 4 s/less ☐ 2 - able to turn 360 degrees safely but slowly ☐ 1 - needs close supervision or verbal cuing ☐ 0 - needs assistance while turning
19	Placing alternate foot on stool	BBS 12	☐ 4 - able to stand independently and safely and complete 8 steps in 20s ☐ 3 - able to stand independently and complete 8 steps in >20s ☐ 2 - able to complete 4 steps without aid with supervision ☐ 1 - able to complete > 2 steps needs minimal assist ☐ 0 - needs assistance to keep from falling/unable to try
20	Standing with one foot in front	BBS 13	☐ 4 - able to place foot tandem independently and hold 30s ☐ 3 - able to place foot ahead independently and hold 30s ☐ 2 - able to take small step independently and hold 30s ☐ 1 - needs help to step but can hold 15s ☐ 0 - loses balance while stepping or standing

The three-balance assessment form (Continued)

No.	Item	Test	Score
21	Standing on non-paretic leg (no other constraints)	BBS14	□ 4 - able to lift leg independently and hold > 10s □ 3 - able to lift leg independently and hold 5-10s □ 2 - able to lift leg independently and hold ≥ 3s □ 1 - tries to lift leg unable to hold 3s but remains standing independently. □ 0 - unable to try of needs assist to prevent fall
		S-BESTest 5	□ 3 - normal: stable for > 20s □ 2 - trunk motion, or 10-20s □ 1 - stands 2-10s □ 0 - unable
		CB&M 1	□ 5 - 45s, steady and coordinated □ 4 - > 20s □ 3 - 10.00 to 19.99s □ 2 - 4.50 to 9.99s □ 1 - 2.00 to 4.49s □ 0 - unable to sustain
22	Standing on paretic leg (no other constraints)	S-BESTest 4	□ 3 - normal: stable for > 20s □ 2 - trunk motion, or 10-20s □ 1 - stands 2-10s □ 0 – unable
		CB&M 2	□ 5 - 45s, steady and coordinated □ 4 - > 20s □ 3 - 10.00 to 19.99s □ 2 - 4.50 to 9.99s □ 1 - 2.00 to 4.49s □ 0 - unable to sustain
23	Change in speed	S-BESTest 11	□ 3 - significantly changes walking speed without imbalance □ 2 - unable to change walking speed without imbalance □ 1 - changes walking speed but with signs of imbalance □ 0 - unable to achieve significant change in speed and signs of imbalance

The three-balance assessment form (Continued)

No.	Item	Test	Score
24	Walk with head turns-horizontal	S-BESTest 12	☐ 3 - performs head turns with no change in gait speed and good balance ☐ 2 - performs head turns smoothly with reduction gait speed ☐ 1 - performs head turns with imbalance ☐ 0 - performs head turns with reduced speed AND imbalance AND/OR will not move head within available range while walking.
25	Timed “Get Up & Go” with dual task	S-BESTest 13	☐ 3 - No noticeable change between sitting and standing in the rate or accuracy of backwards counting and no change in gait speed. ☐ 2 - Noticeable slowing, hesitation or errors in counting backwards OR slow walking (10%) in dual task ☐ 1 - Affects on BOTH the cognitive task AND slow walking (>10%) in dual task ☐ 0 - Can’t count backward while walking or stops walking while talking
26	Tandem walking	CB&M 3	☐ 5 - 7 consecutive steps (in good) ☐ 4 - ≥ 3 consecutive steps (in good alignment) ☐ 3 - > 3 consecutive steps (heel-toe distance < 3") ☐ 2 - 2 to 3 consecutive steps (heel-toe distance < 3") ☐ 1 - 1 step ☐ 0 - unable
27	180° tandem pivot	CB&M 4	☐ 5 - completes 180° turn in a continuous motion and sustains reversed position ☐ 4 - completes 180° turn in a continuous motion but can’t sustain reversed position ☐ 3 - completes 180° turn but discontinuous pivot ☐ 2 - initiates pivot but unable to complete 180° turn ☐ 1 - sustains tandem stance but unable to unweight heels or initiate pivot ☐ 0 - unable to sustain tandem stance

The three-balance assessment form (Continued)

No.	Item	Test	Score
28	Lateral foot scooting in non-paretic	CB&M 5	☐ 5 - 40 cm continuous, rhythmical motion with controlled stop ☐ 4 - 40 cm in any fashion and/or unable to control position ☐ 3 - > 3 pivots but < 40 cm ☐ 2 - 2 lateral pivots ☐ 1 - 1 lateral pivot ☐ 0 - unable
29	Lateral foot scooting in paretic	CB&M 6	☐ 5 - 40 cm continuous, rhythmical motion with controlled stop ☐ 4 - 40 cm in any fashion and/or unable to control position ☐ 3 - > 3 pivots but < 40 cm ☐ 2 - 2 lateral pivots ☐ 1 - 1 lateral pivot ☐ 0 - unable
30	Hopping forward in non-paretic	CB&M 7	☐ 5 - 1 m.in 2 hops, coordinated with stable landing ☐ 4 - 1 m. in 2 hops but difficulty controlling landing ☐ 3 - 1 m. in 2 hops but unable to sustain landing ☐ 2 - 2 hops, controlled but unable to complete 1 m. ☐ 1 - 1 to 2 hops, uncontrolled ☐ 0 - unable
31	Hopping forward in paretic	CB&M 8	☐ 5 - 1 m.in 2 hops, coordinated with stable landing ☐ 4 - 1 m. in 2 hops but difficulty controlling landing ☐ 3 - 1 m. in 2 hops but unable to sustain landing ☐ 2 - 2 hops, controlled but unable to complete 1 m. ☐ 1 - 1 to 2 hops, uncontrolled ☐ 0 - unable
32	Crouch and walk	CB&M 9	☐ 5 - crouches and walks in continuous motion, time < 4s ☐ 4 - crouches and walks in continuous motion, time < 8s excess equilibrium reaction

The three-balance assessment form (Continued)

No.	Item	Test	Score
32	Crouch and walk (Continued)	CB&M 9	☐ 3 - crouches and walks in continuous motion, time < 8s protective step ☐ 2 - descends and rises but hesitates, unable to maintain forward momentum ☐ 1 - able to descend only ☐ 0 - unable to crouch
33	Lateral dodging	CB&M 10	☐ 5 - 2 cycles, contacts line every step < 12s coordinated direction change ☐ 4 - 2 cycles, contacts line every step 12 to 15s ☐ 3 - 2 cycles, contacts line every step ☐ 2 - 1 or more cycles, but does not contact line every step ☐ 1 - 1 cross-over in both directions in any fashion ☐ 0 - unable to perform 1 cross-over in both directions without support
34	Walking & looking: in non-paretic	CB&M 11	☐ 5 - performs, straight path, steady and coordinated < 7s ☐ 4 - performs and maintains visual fixation between 2-6 m mark but veers ☐ 3 - performs and maintains visual fixation between 2-6 m mark but protective step ☐ 2 - performs but loses visual fixation after 4 m mark ☐ 1 - performs but loses visual fixation at or before 4 m mark ☐ 0 - unable to walk and look e.g. stops
35	Walking & looking: in paretic	CB&M 12	☐ 5 - performs, straight path, steady and coordinated < 7s ☐ 4 - performs and maintains visual fixation between 2-6 m mark but veers ☐ 3 - performs and maintains visual fixation between 2-6 m mark but protective step ☐ 2 - performs but loses visual fixation after 4 m mark ☐ 1 - performs but loses visual fixation at or before 4 m mark ☐ 0 - unable to walk and look e.g. stops

The three-balance assessment form (Continued)

No.	Item	Test	Score
36	Running with controlled stop	CB&M 13	☐ 5 - runs, time < 3s, with controlled stop, both feet on line, coordinated and rhythmical ☐ 4 - runs, time < 3s, unable to control stop ☐ 3 - runs, time > 3 but < 5s, with controlled stop, both feet ☐ 2 - runs, time > 3 but < 5s, unable to control stop ☐ 1 - runs, time > 5s ☐ 0 - unable to run
37	Forward to backward to walking	CB&M 14	☐ 5 - performs in < 7.00 sec., maintains straight path ☐ 4 - performs in < 9.00 sec. and/or uses protective step during or just after turn ☐ 3 - performs in < 11.00 sec. and/or veers during backward walking ☐ 2 - performs with reduced speed, time > 11.00 sec. or requires 4 or more steps to turn ☐ 1 - performs but must stop to regain balance ☐ 0 - unable
38	Walk, look and carry: in non-paretic	CB&M 15	☐ 5 - performs, straight path, steady and coordinated < 7s ☐ 4 - performs and maintains visual fixation between 2-6 me mark but veers ☐ 3 - performs and maintains visual fixation between 2-6 m mark but protective step ☐ 2 - performs but loses visual fixation after 4 m mark ☐ 1 - performs but loses visual fixation at or before 4 m mark ☐ 0 - unable to walk and look e.g. stops
39	Walk, look and carry: in paretic	CB&M 16	☐ 5 - performs, straight path, steady and coordinated < 7s ☐ 4 - performs and maintains visual fixation between 2-6 me mark but veers ☐ 3 - performs and maintains visual fixation between 2-6 m mark but protective step

The three-balance assessment form (Continued)

No.	Item	Test	Score
39	Walk, look and carry: in paretic (Continued)	CB&M 16	☐ 2 - performs but loses visual fixation after 4 m mark ☐ 1 - performs but loses visual fixation at or before 4 m mark ☐ 0 - unable to walk and look e.g. stops
40	Descending stairs	CB&M 17	☐ 5 - full flight reciprocal, rhythmical and coordinated +1 bonus for carrying basket ☐ 4 - full flight reciprocal, awkward ☐ 3 - 3 steps reciprocal or full flight in step-to pattern ☐ 2 - able to step down 3 steps with/without cane, any pattern ☐ 1 - able to step down 1 step with/without cane ☐ 0 - unable to step down 1 step, or requires railing or assistance
41	Step-ups X 1 step: in non-paretic	CB&M 18	☐ 5 - completes 5 cycles in < 6s, rhythmical ☐ 4 - completes 5 cycles in > 6 but < 10s ☐ 3 - completes 5 cycles ☐ 2 - steps up and down (1 cycle) ☐ 1 - steps up, requires assistance or railing to descend ☐ 0 - unable to step up, requires assistance or railing
42	Step-ups X 1 step: in paretic	CB&M 19	☐ 5 - completes 5 cycles in < 6s, rhythmical ☐ 4 - completes 5 cycles in > 6 but < 10s ☐ 3 - completes 5 cycles ☐ 2 - steps up and down (1 cycle) ☐ 1 - steps up, requires assistance or railing to descend ☐ 0 - unable to step up, requires assistance or railing

APPENDIX D

APPENDIX D
ABBREVIATION

Abbreviation	Meaning
95% CI	95% Confidence interval
ABC	Activities-Specific Balance Confidence Scale
BBS	Berg balance scale
BESTest	Balance Evaluation Systems Test
BI	Barthel index
BMI	Body Mass Index
Brief-BESTest	Brief-Balance Evaluation Systems Test
CB&M	Community balance and mobility scale
cm	Centimeters
CMSA	Chedoke-McMaster stroke assessment
Cronbach's α	Cronbach's Alpha
D	Day
DALYs	Disability-adjusted life-years
DGI	Dynamic Gait Index
Domain I	Muscular strength & biomechanical constrains domain of the S-BESTest
Domain II	Stability limit & internal representation of verticality domain of the S-BESTest
Domain III	Anticipatory postural adjustment domain of the S-BESTest
Domain IV	Reactive postural response domain of the S-BESTest
Domain V	Sensory orientation domain of the S-BESTest
Domain VI	Stability in gait domain of the S-BESTest
ES	Effect size

Abbreviation (Continued)

Abbreviation	Meaning
FMA	Fugl-Meyer Assessment
FMA-B	Fugl-Mayer assessment-balance subscale
FMA-LE	Fugl-Mayer Assessment-lower extremity subscale
FRT	Functional Reach Test
GDS	Geriatric Depression Scale-Short Form
ICC	Intraclass Correlation Coefficient
kg	Kilograms
kg/m^2	Kilograms per square meters
MAS	Motor Assessment Scale
Min	Minutes
Mini-BESTest	Mini-Balance Evaluation Systems Test
n	Number of participants
NRS	Numerical Rating Scales
PASS	Postural Assessment Scale for Stroke
r	Correlation coefficient
Rater KS	Rater Kanokpich Satayaprakorb
Rater OI	Rater Olan Isariyapan
Rater PE	Rater Piyatad Eakkabut
Rater PS	Rater Phapvijit Seangsanor
Rater TD	Rater Thammarat Dechmark
Researcher TW	Research consultant Thitimard Winairuk
Researcher BC	Research consultant Butsara Chinsongkram
Researcher NC	Research consultant Nithinun Chaikeeree
S-BESTest	Stroke-Balance Evaluation Systems Test

Abbreviation (Continued)

Abbreviation	Meaning
SD	Standard deviation
SRM	Standardized Response Mean
TUG	Timed up and go test
TWT	Timed walking test

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