The Contribution of Muscle Tone, Upper Limb and Lower Limb Motor Functions on Fall History in Community-Dwelling Individuals with Stroke

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Abstract

This study aimed to determine the associations between motor performance relating to disability after stroke with fall history in the past six months. The measurements consisted of Modified Ashworth Scale of Elbow Flexors (MAS-EF) and Ankle Plantar Flexor (MAS-APF), Fugl Meyer Assessment of Upper Extremity (FMA-UE) and Lower Extremity (FMA-LE), Ankle Plantar flexor Strength (APF-strength), Step Test (ST), Berg Balance Scale (BBS), and Timed Up & Go Test (TUG). A fall history of six months was interviewed using a standardized questionnaire. Binary logistic regression was used to indicate the relationship between the measure and fall history. Crude odd and adjusted odds ratio (AOR) were presented. Two hundred and forty-eight first stroke patients living at home participated in the study. The results showed that the participants increased fall risks when they had spasticity of elbow flexor (AOR: 3.11; 95%CI: 1.29, 7.55) and ankle plantar flexor (AOR:3.24; 95%CI:1.43, 7.33) and took a long time for TUG (AOR:1.02; 95%CI: 1.01, 1.03). The preventive of falls were ability of motor performance and balance control including upper extremity control (AOR of FMA-UE: 0.98; 95%CI: 0.96, 0.99) and lower extremity control (AOR of FMA-LE: 0.92; 95%CI: 0.89, 0.98), ankle plantar flexor strength (APF-StrengthAOR:0.98; 95%CI: 0.98, 0.99) and ability to taking weight on weakness leg (AOR of ST: 0.82; 95%CI: 0.74, 0.90). The findings showed that motor impairment of upper and lower extremities in community-dwelling with stroke influenced falls in individuals with stroke who live at home. Thus, the training of motor performance should be included in the fall prevention program.

Keywords: Motor performance, Muscle tone, Fall

1. Introduction

Individuals with stroke sustain a fall after discharge from hospitals. A high risk of falling is reported in individuals living in the community. Almost half of community-dwelling individuals with stroke had at least fall once, the highest falling rate reaches 49% and 26 % of them experienced repeated falls in the first year (Walsh et al., 2018). The high fall rate causes the concern of public health because of devastating consequences, both physically and psychosocially. Fractures are frequently considered as severe physical injuries after falls. The incidence rate of fracture was 2.8 per 100 person-years (Goto et al., 2019). Although no serious injury has occurred, falls following stroke were major reasons for receiving medical treatments and the high cost of care (Walsh et al., 2018).

To prevent falls and minimize any adverse effects, relatively much research has put a lot of effort to identify the etiology of falls. Disability following stroke is one of the important factors of falls. The most considerable factors are related to poor balance and gait deficits (Jalayondeja, Sullivan, & Pichaiyongwongdee, 2014). Individuals with stroke frequently fall during walking (Goto et al., 2019). Lower limb performance including movement, muscle strength, and muscle tone influence postural stability in standing (Hendrickson, Patterson, Inness, McIlroy, & Mansfield, 2014; Mansfield, Inness, Lakhani, & McIlroy, 2012). Ankle plantar flexors muscle strength and tone have importance for walking (Goldberg, Anderson, Pandy, & Delp, 2004; You, Chung, & Lee, 2016). Besides, the upper limb function is essential for recovering balance during unexpected events (Marigold & Patla, 2002).

Obviously, individuals with stroke lose balance during walking. The contribution of the upper and lower limbs on gait and postural control has been reported. Hence, the purpose of the present study was to determine whether the body function impairments following stroke including movement control of UE and LE, presenting spasticity of the upper limb and lower limb, ankle plantar flexor strength, tone of ankle plantar flexor were related to the history of falls.

2. Objectives

To examine the relationship between the upper limb and lower limb performance with fall history in the past 6 months in community-dwelling individuals with stroke

3. Materials and Methods

The protocol has been approved by the Ethical Community of Mahidol University (MU-IRB 2014/042.1903/COA No. 2014/060.0805). A clinical trial has been submitted to the Thai Clinical Trials Registry (TCTR2017023001). The study was conducted according to the Declaration of Helsinki ethical principles for human experimentation.

The study was a multi-site, cross-sectional, observational design. The participants were in the home visit program of primary health care units, were the patients of the outpatient department in hospitals, or were the patients of physical therapy clinics. If the individuals with stroke volunteer to participate in the study, the researcher set a schedule for a single study session (90 minutes). Four physical therapists had been trained to perform the data measurement outcome, and intra- and inter- reliabilities were good for all outcomes. The measurement was completed at the participants' homes in four provinces in Thailand; Bangkok, Pathum Thani, Nonthaburi, and Samutprakarn.

The participants were 248 community-dwelling individuals with stroke aged 35 years or older. They had a unilateral first-time stroke in the past 6 months, had a score of the Thai Mini-Mental State Examination (TMSE) greater than 24, and were able to walk independently with or without gait devices for 6 meters and modified Rankin scale (mRS) 2-4. The exclusion criteria were to have unilateral neglect, severe aphasia or major comprehensive deficits, visual field deficits and double visions, a history of lower-extremity fractures within the past 6 months, or other neurological diseases such as Parkinson's disease and multiple sclerosis.

Demographic characteristics and medical history recorded by the questionnaire included age, gender, weight, height, etiology of stroke, and side of weakness, date of stroke onset, disability level, mRS, living arrangement, and comorbidities.

A Fall was defined as "an episode of unintentionally coming to rest on the ground or lower surface that was not the result of dizziness, fainting, sustaining a violent blow, loss of consciousness, or other overwhelming external factors." The participants or their caregivers reported falls in the last 6 months or after discharge from hospitals by a face-to-face interview via the standardized questionnaire. Fall history was generated to categorize participants with having a history of falls and those who had not fallen. Moreover, participants reported the circumstances of falls such as the place, time, cause, landing side, associated activities, and injuries during falls.

Outcome measures

Modified Ashworth Scale (MAS) is a scale that represents the severity of spasticity. The scale ranges from no increase in muscle tone through to the rigid of the affected part in flexion or extension. The measure was applied to the elbow flexors (MAS-EF) and the ankle plantar flexor (MAS-APF). The scale ranged from 0 to 4 (0, no increase in muscle tone; 4, rigid in flexion or extension) (Bohannon & Smith, 1987). The MAS score showed a moderate positive correlation with the parameters of surface EMG, which indicated that MAS was associated with stretch response activity (Cooper, Musa, van Deursen, & Wiles, 2005).

The Fugl-Meyer Assessment (FMA) commonly evaluates motor recovery patterns after stroke attacks (Fugl-Meyer, Jääskö, Leyman, Olsson, & Steglind, 1975). The FMA is one of the performance measures based on the ontogenetic concept through the assessment of volitional movements within synergies, partial out synergy, and independent of synergy. The FMA has well-reported the reliability and validity as efficient for evaluation motor impairment severity across different stages of stroke. For the measurement of inter-rater reliability of motor subscale, the intra-class correlation coefficients (ICCs) in 6 days to 6 months post-stroke were good, upper extremity at 0.97 (95% CI: 0.94-0.99) and lower extremity at 0.92 (95 % CI: 0.81-0.96) (Sanford, Moreland, Swanson, Stratford, & Gowland, 1993). Both upper and lower limb subscales were scored on a 3-point ordinal scale; 0 = no function, 1 = partial motion, and 2 = full motion. The total score (100) computed by summing the score from FMA-upper extremity (FMA-UE (0-66), and FMA-lower extremity (FMA-LE) (0-34) (Fugl-Meyer et al., 1975), which has a unidimensional and hierarchical characteristic (Crow & Harmeling-Van Der Wel, 2008).

Ankle plantar flexor strength (APF strength) is measured by a handheld dynamometer, which is widely used in research (Kluding & Gajewski, 2009). Power Track™ II Commander handheld dynamometer (JTECH Medical, Salt Lake City, UT, USA) is commonly used in the study of muscle strength (Lin, Yang, Cheng, & Wang, 2006). The strength of the ankle plantar flexor was taken in a supine position. Each participant performed a submaximal familiarization trial after that the maximal isometric contraction for 5 seconds, 3 trials with 15-second rest in between. The measurement of the muscle on the other side was conducted after a 1-minute rest. The order of measurement was a nonparetic limb first and then a paretic limb to ensure that the participant knew the correct muscle group to contract. Instructions for the participants were to hold the position. The verbal command for the action was "push...hold, hold, hold, relax."

Step Test (ST) was used to assess weight-bearing abilities in standing in individuals with stroke (Mercer, Freburger, Chang, & Purser, 2009). The result of linear regression demonstrated a high relationship between the non-paretic limb ST score and peak vertical ground reaction forces (GRFs) during various tasks, diagonal task (r2=0.42), sit-to-stand task (r2=0.35), and stepping with a nonparetic limb (r2 =0.76). Moreover, peak vertical GRFs beneath the paretic limb during various functional tasks accounted for 35% to 76% of the variance in the ST scores, with peak vertical GRFs during stepping (nonparetic limb leading) having the strongest relationship. Besides, excellent inter-rater reliability was found between the 2 experienced examiners (paretic, ICCs=0.997–0.998; nonparetic, ICCs=0.996 –0.998) and between the 2 experienced and 2 inexperienced examiners (paretic, ICCs=0.996 –0.999; nonparetic, ICC=0.997–0.999) (Mercer et al., 2009)

Berg Balance Scale (BBS) is the most popular balance measurement tool. It consists of 14 items to quantify balance abilities. Each item relates to the ability of individuals to maintain upright positions and to adjust voluntary movements. The scoring method is based on a 5-point scale (0-4) (Berg, Wood-Dauphinee, & Williams, 1995). The psychometric properties of the BBS used in individuals with stroke were examined in several studies with supportive results. The test is reported to have excellent inter-rater reliability (0.99), and very good internal consistency (Cronbach's alpha = 0.97) (Blum & Korner-Bitensky, 2008).

Timed Up and Go Test (TUG) is developed to evaluate anticipatory aspects of postural control associated with functional mobility (rising from a chair, walking, turning, and sitting down). The score is the actual time to complete the test. Importantly, the test requires a short distance for walking (3 meters) (Podsiadlo & Richardson, 1991). TUG showed to be a reliable and valid test for examining mobility following stroke and had very good interrater reliability (ICC= 0.99) in elderly people with various medical conditions (Podsiadlo & Richardson, 1991).

Data analysis

SPSS version 19 was performed to explore and compare the characteristic of participants between the individuals with no falls, and with a history of falls. The suitability of continuous variables to normal distribution was tested by the Kolmogorov–Smirnov test and data were analyzed using the Student's t-test (parametric data) and Mann–Whitney U-test (non-parametric data). Discrete variables were analyzed using the x^2-test. Statistical significance was reached at $p < 0.05$. Multivariate logistic regression was analyzed using the forward stepwise method to identify body structure impairments and activity limitations that were independently associated with a history of falls. Crude and adjusted odds ratios were obtained from the estimated coefficients with a 95% confidence interval (CI) of the ratio. The adjusted odds ratio was considered for age, gender, BMI, mRS, time since stroke, weakness side, the presence of hypertension, and the presence of diabetes mellitus.

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4. Results and Discussion

4.1 Results

A total of 255 individuals with stroke enrolled in the study. Seven cases moved to the outside areas before the data collection, therefore, 248 participants joined the study. In the past six months, 100 participants had falls (40%) while 148 did not (60%). For the participants in the falls group, 75 of them fell one time, and 25 had multiple falls. The average number of falls was 0.55 ± 0.84 (range 0-6). The characteristics of 248 participants who participated in the study were shown in Table 1. The comparisons of demographics showed that both subgroups were similar, except mRS.

Table 1 Overall characteristics of participants

Characteristics	**Whole participants n=248**	**With falls group n=100**	**Without falls group n=148**	***p*-value**
Age (years), mean ± SD	61.9 ± 0.7	62.2 ± 10.2	61.8 ± 10.4	0.733
Gender				
Male	164 (66.1)	64 (25.8)	100 (40.3)	0.560
Female	84 (33.9)	36 (14.5)	48 (19.4)	
BMI (kg/m^2),	23.8	23.8	23.8	0.693
median (range)	(15.6-38.5)	(15.6-38.5)	(15.8-37.7)	
Etiology				
Ischemic	178 (71.8)	73 (29.4)	105 (42.4)	0.655
Hemorrhage	70 (28.2)	27 (10.9)	43 (17.3)	
Weakness side				
Right	134 (54.0)	47 (19.0)	87 (35.0)	0.068
Left	114 (46.0)	53 (21.4)	61 (24.6)	
Stroke length (mths), median (range)	37.5	39.5	36.5	0.501
	(7.0-264.0)	(7.0-246.0)	(7-264.0)	
mRS				
mRS = 2	37 (14.9)	10 (4.0)	27 (10.9)	
mRS = 3	184 (74.2)	71 (28.6)	113 (45.6)	0.001*
mRS =4	27 (10.9)	19 (7.7)	8 (3.2)	
Living arrangement				
Family	241 (97.2)	96 (38.7)	145 (58.5)	0.357
Alone	7 (2.8)	4 (1.6)	3 (1.2)	
Reported comorbidities				
Hypertension	204 (82.4)	88 (35.5)	116 (46.8)	0.052
Diabetes	68 (27.4)	34(13.7)	34 (13.7)	0.056
Hypercholesterolemia	42 (16.9)	20 (8.1)	22 (8.9)	0.364
Heart disease	5 (2.0)	2 (0.8)	3 (1.2)	NA
Other				
Gout	2 (0.8)	0 (0.0)	2 (0.8)	NA
Osteoarthritis	4 (1.6)	4 (1.6)	0 (0.0)	NA
Hyperthyroidism	1 (0.4)	1 (0.4)	0 (0.0)	NA
Liver cirrhosis	1 (0.4)	0 (0)	1 (0.4)	NA
Asthma	4 (1.6)	1 (0.4)	3 (1.2)	NA
Polycythemia vera	1 (0.4)	1 (0.4)	0 (0.0)	NA
Breast cancer	1 (0.4)	0 (0.0)	1 (0.4)	NA
Chronic obstructive pulmonary disease	2 (0.8)	2 (0.8)	0 (0.0)	NA
Congenital heart disease	1 (0.4)	0 (0.0)	1 (0.4)	NA

Prostatic hyperplasia	1 (0.4)	0 (0.0)	1 (0.4)	NA
Kidney disease	3 (1.2)	2 (0.8)	1 (0.4)	NA

Note. Values are n (%) or otherwise indicated. *P*-value derived from chi-square test for gender, etiology, weakness side, and reported comorbidities, Mann–Whitney U-test for age, BMI, and Fisher's exact test for the living arrangement. Statistical significance is at $p < .05$.
Abbreviation. BMI: body mass index; mRS: modified Rankin scale; NA: not applicable

As shown in Table 2, the participants showed a significant different score of MAS-Elbow flexor (p < 0.001) and MAS-Ankle plantar flexor (p = 0.006) between groups. The participants in the fall group showed a significantly less score of FMA-UE (p < 0.001), FMA-LE (p < 0.001), FMA-Total (p < 0.001), APF-Strength (p = 0.001), ST (p < 0.001), and BBS (p < 0.001) and used more time for TUG (p = 0.001) than those in the group without fall.

Table 2 Characteristics of motor performance and balance of the participants

Variables	Whole participants n = 248	With fall group n = 100	Without fall group n = 148	*P* value
MAS -EF, n (%)				
Grade 0	43 (17.3)	9 (3.6)	34 (13.7)	
Grade 1	58 (23.4)	16 (6.5)	42 (16.9)	<0.001**
Grade 1+	50 (20.2)	27 (10.9)	23 (9.3)	
Grade 2	50 (20.2)	19 (7.7)	31 (12.5)	
Grade 3	28 (11.3)	18 (7.3)	10 (4.0)	
Grade 4	19 (7.7)	11 (4.4)	8 (3.2)	
MAS-APF, n (%)				
Grade 0	57 (23.0)	13 (5.2)	44 (17.7)	
Grade 1	45 (18.1)	14 (5.6)	31 (12.5)	
Grade 1+	24 (9.7)	12 (4.8)	12 (4.8)	
Grade 2	46 (18.5)	21 (8.5)	25 (10.1)	0.006*
Grade 3	45 (18.1)	22 (8.9)	23 (9.3)	
Grade 4	31 (12.5)	18 (7.3)	13 (5.2)	
FMA-UE (scores)	37.0 (2.0-66.0)	20.5 (4.0-66.0)	42.5 (2.0-66.0)	<0.001**
FMA-LE (scores)	22.5 (6.0-34.0)	19.5 (6.0-34.0)	24.0 (6.0-34.0)	<0.001**
FMA-Total (scores)	61.0 (10.0-99.0)	42.0 (10.0-98.0)	66.50 (14.0-99.0)	<0.001**
APF-Strength (% of the unaffected APF)	52.4 (0.0-98.9)	40.5 (0.0-98.9)	55.7 (0.0-97.1)	0.001*
ST (number of steps)	6.0 (0.0-15.0)	5.0 (0.0-12.0)	7.0 (0.0-15.0)	<0.001**
BBS (scores)	41.0 (4.0-55.0)	38.0 (4.0-55.0)	45.5 (4.0-55.0)	<0.001**
TUG (seconds)	28.4 (10.7-300.0)	34.2 (13.7-300.0)	26.1 (10.7-130.0)	0.001*

Note. Values are median (range) or otherwise indicated. *P*-value derived from chi-square test for MAS of elbow flexor and ankle plantar flexor, Mann-Whitney *U* test for FMA-UL, FMA-LL, FMA-Total, ankle plantar flexor strength, ST and BBS. Significance at $p < .05$, * P-value < .05, ** P-value < .001
Abbreviation. MAS-EF: modified Ashworth Scale of elbow flexor; MAS-APF: modified Ashworth Scale of ankle plantar flexor; FMA-UE: Fugl Meyer Assessment-Upper Extremity portion; FMA-LE: Fugl Meyer Assessment-Lower Extremity portion; FMA-Total: Fugl Meyer Assessment total score; APF-Strength: ankle plantar flexor strength; ST: Step Test; BBS: Berg Balance Scale; TUG: Time Up and Go Test.

The relationships between the measures and fall episodes

Binary logistic regression crude and adjusted Odds Ratio (OR) and a 95% Confidence Interval (CI) were performed to estimate the independent contribution of each variable to the probability of falls (Table 3). An OR greater than 1 indicated the likelihood of no falls, whereas an OR less than 1 showed a high probability of having falls. Since, the demographic data including age, gender, BMI, time since stroke, mRS, weakness side, presenting hypertension, and presenting diabetes mellitus were considered as potential confounders, the odds were adjusted. To describe the relationship of the measures with falls, the adjusted OR with $p < 0.05$ was in considerations.

The MAS-EF and MAS-APF were categorized into two groups as MAS < 1 and MAS ≥ 1. The participants with MAS of EF and PF ≥ 1 had about 3 times of falls compared with those who had MAS < 1. The result showed crude OR and the adjusted OR of FMA-UL, FMA-LL, FMA-Total, and PF-Strength were statistically significant. With the increase of 1 unit of FMA-UE, FMA-LE, and APF-Strength, the rate of falls increased 0.98, 0.92, and 0.98 times, respectively. The OR of TUG was greater than 1, indicating the increase of 1 unit of TUG, the rate of fall increases 1.02 times. In contrast, the OR of ST and BBS was less than 1, presenting the rate of fall increased, 0.82, and 0.93 times as the score of ST, and BBS increased 1 unit, respectively.

In conclusion, the OR of MAS-EF, MAS-PF, and TUG were greater than 1 whereas the OR of FMA-UE, FMA-LE, FMA-Total, APF-Strength, ST, and BBS were less than 1. Among these variables, the OR of ST was lowest, while the OR of MAS-EF and MAS-PF were highest.

Table 3 The relationship between the measurement and fall in the past 6 months presented by crude and adjusted odds ratios (n=248)

Variables	Crude odds ratio (95%CI)	p-value	Adjusted odds ratio [a] (95%CI)	p-value
MAS-EF				
Grade < 1	reference			
Grade ≥ 1	2.98 (1.31, 6.78)	0.009*	3.11 (1.29, 7.55)	0.012*
MAS-APF				
Grade < 1	reference			
Grade ≥ 1	2.96 (1.43, 6.11)	0.003*	3.24 (1.43, 7.33)	0.005*
FMA-UL	0.98 (0.97, 0.99)	0.001*	0.98 (0.96, 0.99)	0.004*
FMA-LL	0.93 (0.90, 0.97)	<0.001**	0.92 (0.89, 0.98)	0.003*
FMA-Total	0.98 (0.97, 0.99)	<0.001**	0.98 (0.97, 0.99)	0.002*
APF-Strength	0.99 (0.98, 0.99)	0.002*	0.98 (0.98, 0.99)	0.010*
ST	0.82 (0.76, 0.89)	<0.001**	0.82 (0.74, 0.90)	<0.001**
BBS	0.93 (0.91, 0.96)	<0.001**	0.93 (0.90, 0.97)	<0.001**
TUG	1.02 (1.01, 1.03)	<0.001**	1.02 (1.01, 1.03)	0.003*

[a] Odds ratio adjusted for age, gender, BMI, mRS, time since stroke, weakness side, the presence of hypertension, and the presence of diabetes mellitus.

* P value < .05

Abbreviation. MAS-EF: modified Ashworth Scale of elbow flexor; MAS-APF: modified Ashworth Scale of ankle plantar flexor; FMA-UE: Fugl Meyer Assessment-Upper Extremity portion; FMA-LE: Fugl Meyer Assessment-Lower Extremity portion; FMA-Total: Fugl Meyer Assessment total score; APF-Strength: ankle plantar flexor strength; ST: Step Test; BBS: Berg Balance Scale; TUG: Time Up and Go Test.

4.2 Discussion

The present study found the contribution of motor impairments and balance on fall history in the prior 6 months. These findings indicated the impact of motor impairment on the fall risk of community-dwelling individuals with stroke and may guide intervention strategies focused on fall prevention. The rate of falls (40%) in the present study was similar to the previous study (Belgen, Beninato, Sullivan, & Narielwalla, 2006) that using the same duration for collecting fall history data. The rate was higher than 35% for those who were discharged from the inpatient rehabilitation center with follow-up falls for 6 months (Mansfield et al., 2015). A large number of participants in this study was a chronic stroke enrolled from the community, which may affect the fall rate reported. The participants were individuals with stroke ambulating and were young elderly. The number of whole participants was the greatest in moderate disability and the lowest in moderately severe disability. A previous study showed that individuals with moderate-severe presented by mRS were at higher risk of falls than those with severity as mild (Wei et al., 2019). Similarly, the number of participants with moderately severe disabilities in the faller group was higher than those in the non-faller group.

The participants with motor impairment of upper limb including increased elbow flexor muscle tone (OR=3.12; 95%CI: 1.29, 7.55) and less score of FMA-UE (OR = 0.98, 95%CI: 0.96, 0.99) had higher fall possibility. Spasticity of elbow flexors resulted in delayed movement time in reaching activity (Cirstea, Mitnitski, Feldman, & Levin, 2003). Upper limb motor deficits may cause a late arm protective strategy. Lower extremity performance measured by MAS-APF, FMA-LE, APF-strength, influenced on falls. However, other studies showed a known association between motor impairment and falls, variations in subject's time since stroke, fall recording periods, and kinds of measurement in different studies may discuss the differences (Xu et al., 2018). The participants with spasticity of PF had the tendency of falls than those with normal muscle tone (OR=3.24; 95%CI: 1.43, 7.33). The result agreed with a previous report (Soyuer & Oztürk, 2007). Increased PF spasticity reduced balance performance measured by BBS and TUG (V. Hiengkaew, Jitaree, & Chaiyawat, 2012; Wu et al., 2006). The score of FMA-LE in the individuals in the group of falls was 19.5 and associated with falls (OR: 0.93; 95% CI: 0.89, 0.98). Similarly, a previous finding found individuals with impaired lower limb function (FMA-LL $\leq$ 28) had 2.20 times of falls (95%CI: 1.05,4.70), compared to those with good lower limb control. (Yates, Lai, Duncan, & Studenski, 2002). Individuals with stroke who have poor control of muscle in the lower limb presented a great weight-bearing asymmetry (Roerdink, Geurts, de Haart, & Beek, 2009), loss of stability during slip (Dusane, Gangwani, Patel, & Bhatt, 2021). Since the value of crude and adjusted odds ratio of AP-strength closed to 1.00, it may be that ankle plantar flexor muscle strength was not an important preventive factor of falls. During the stance phase in the gait cycle, ankle plantar flexor muscles worked together with ankle dorsiflexor muscles to increase joint stability. Thus, the measure of ankle muscle strength may include dorsiflexor muscles (Kitatani et al., 2016).

The present study also identified the weight-bearing asymmetry using ST. The findings showed that an increase in ST scores reduced the rate of falls (OR=0.82; 95%CI: 0.74, 0.90). During stepping with an unaffected leg, a decrease in weight transfer in the affected leg causes instability in standing with a single limb (Kajrolkar & Bhatt, 2016). The present finding agrees with the prior report (Belgen et al., 2006) and indicated that TUG may not well associated with fall history in individuals with stroke. The previous study demonstrated that TUG was significantly predictive of falls provided by recording falls for a 12-month calendar. (Bower et al., 2019). It is, therefore, suggested to cautions the TUG as a measurement risk of falls in the different study designs.

This study protocol had limitations. Firstly, participants were individuals with stroke living at home. Therefore, the finding may not explain falls in individuals with stroke in acute or subacute stages or those staying at the hospital or in nursing homes. Secondly, mobility level was not investigated, because of the restriction of space in the participant's home. Lastly, the study specially measured physical impairment, factors such as depression and using the sedative drug were not investigated.

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5. Conclusion

This study indicated that motor impairment of the upper and lower extremities in community-dwelling with stroke had contributions on falls in individuals with stroke who live at home. It is suggested that the assessment of the control of the upper and lower extremity help to identify the individuals with stroke at high risk of falls. Moreover, the finding supported the essential of motor control improvement in fall prevention programs.

6. Acknowledgements

We thank Butzara Chinsongkram, Saranyoo Roopanvong, Warisa Supradit, Pathaveena Kaewjaeng for data collection. Our thanks is also extended to physical therapists, nurses, public health personals, and health volunteers who aided in this study

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