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Problems of lower limb loading symmetry during sit-to-stand in ambulatory individuals with stroke

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KEYWORDS

Rehabilitation; Cerebrovascular accident; Walking; Stability.

ABSTRACT

Existing evidence on lower limb loading symmetry and movement stability of patients with stroke commonly involves data during standing and stepping, without clear evidence for sit-to-stand (STS) ability. This study investigated the lower limb loading during sit-to-stand (LLL-STS) in 39 ambulatory individuals with chronic stroke during usual and optimal conditions using digital load cells as compared to those found in 10 healthy individuals. During the tests, participants were instructed to perform a sit-to-stand movement in 2 conditions, including 1) at their usual manner, and 2) at their optimal manner with the attempt to put their body-weight on the lower limbs as symmetrically as they could. The findings indicated that the participants had maximal LLL-STS of 47% and 75% of their body-weight in the affected and non-affected limb, respectively, resulting in the LLL-STS symmetry of 62%, whereas the LLL-STS symmetry in healthy individuals were nearly 100%. However, the LLL-STS symmetry of stroke participants was significantly increased to 73% when they attempted to take body-weight onto both lower extremities equally. The findings suggested that the participants retained some capability that they did not usually access. The findings suggested the use of verbal commands as an alternative rehabilitation strategy to promote LLL-STS symmetry of individuals with chronic stroke.

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Introduction

The unilateral sensorimotor dysfunction following stroke commonly limit the ability of lower limb loading (LLL) of the affected limb that distorts movement stability, and ability to perform functional activities independently of the patients(1-3). Based on the concept of task-specific practice, previous studies often emphasized on the LLL of the affected limb during standing or stepping(4-6). In fact, a sit-to-stand (STS) task is a basic and pre-requisite ability for many daily activities that is mechanically demanding greater than that need for standing and walking(7). Therefore, the amount of lower limb loading during sit-to-stand (LLL-STS) may be obviously deviated in such challenging task and subsequently impair ability to conduct other daily activities, levels of independence, and safety of these individuals.

The existing evidence reported that the mean LLL-STS on the affected leg of the patients was 37%(8) and there was 16% of the body-weight excess on the non-affected limb(9). However, these data were derived from different studies(8, 9), thus it may not be clearly reflecting LLL-STS on the lower extremities and LLL-STS symmetry. Therefore, this study investigated the data relating to LLL-STS during usual and optimal conditions in ambulatory individuals with chronic stroke as compared to the data from healthy individuals who had gender and age matched (± 5 years). The findings would confirm the problems and effects of verbal commands on LLL-STS symmetry of ambulatory individuals with stroke.

Materials and methods

Participants

This cross-sectional study was conducted in ambulatory patients with the first chronic stroke episode because they were in a stable stage with difficult to make change according to any training tasks. The inclusion criteria were age at least 40 years with the ability to communicate or follow the commands used in this study, and ability of independent walking with or without a walking device over at least 10 meters with post-stroke duration more than 6 months. The exclusion criteria were any other neurological and medical conditions that might affect ability to participate in the study, such as uncontrolled underlying diseases (i.e. hypertension, heart disease, thyroid, etc.), visual deficits that were unable to be corrected using glasses or contact lens, pain with a score more than 5 out of 10 on a visual analog scale, and deformity in the joints of the lower extremities. The number of participants in this study was derived from a major study(10). All procedures of the study were in accordance with the standards of the Khon Kean University Ethics Committee for Human Research (HE601350). All participants read and signed a written informed consent before participation in the study.

Research protocols

The eligible participants were interviewed and assessed for their demographics (i.e., age, gender, body weight and height), stroke characteristics (i.e., cause, post-stroke time, hemiplegic side), and ability of walking with or without a walking device over at least 10 meters. Then, they were evaluated for their LLL-STS using digital load cells (4 half-bridge weigh sensors, total rated load 200 kg, with standard calibration method based on UKASLAB 14: 2006, accuracy up to 0.1 kg and measurement uncertainty of ±0.082 kg/side)(10). Participants sat on a standard armchair in a standard sitting position, with their back upright against the backrest of the chair, and feet placed flat on the digital load cells (11, 12). Then they were instructed to stand up from the chair in 2 conditions including;

Usual condition: Participants were instructed to perform STS with or without using their arms as they normally performed in their daily living.

Optimal condition: Participants were instructed to perform STS with the attempt to adequately take their body-weight onto both feet as good as they could, with or without using their arms.

The data relating to LLL-STS (including minimum, maximum, average, and duration) were recorded automatically by the digital load cells when the participant's back moved away from the backrest of the chair until their back touching the backrest again after completing the test. The average finding of each condition over 3 trials was used for data analysis.

Statistical analysis

Descriptive statistics were used to explain demographics, stroke characteristics, and findings of the study. The dependent samples t-test was applied to compare the difference of LLL-STS between the lower limbs of the participants. The independent samples t-test was utilized to analyze the LLL-STS symmetry between participants with stroke and healthy individuals. The level of significant differences was set at *p*-value < 0.05.

Results

Thirty-nine participants with chronic stroke were involved in the study. Most of them were male, with right hemiplegia, and used a walking device for daily living (Table 1). Their demographics showed no significant differences from healthy individuals (n = 10, *p*-value>0.05, Table 1).

Table 1 Demographic data of healthy individuals and stroke participants

Variable	Healthy individual (n=10)	Stroke participants (n=39)	P-Value
Demographic			
Age[a] (years)	60.8±9.7	59.4±7.4	*0.63*
	(53.9 – 67.7)	(57.0 – 61.8)	
Body mass index[a] (kg/m^2)	23.2±3.3	24.6±3.4	*0.26*
	(20.9 - 25.6)	(23.5 - 25.7)	
Gender[b]: male	6 (60.0)	31 (69.2)	*0.58*
Non-dominant leg/ Hemiplegic side[b]: Right side	9 (90.0)	16 (41.0)	*0.016*
Post-stroke time[a] (month)		41.97±21.23	
Walking device requirement[b]: Yes		19 (48.7)	

Note: [a] The data are presented using mean±SD (95% confidence interval), and the comparisons between the groups were analysed using the independent samples t test.
[b] The data are presented using number (percent), and the comparisons between the groups were analyzed using the Chi-square test.
Gender: male/female; Non-dominant leg/ hemiplegic side: right side/left side; Stage of stroke: chronic/ subacute; Walking device requirement: yes/no

Healthy individuals showed symmetrical LLL-STS of the lower extremities, that resulted in LLL-STS symmetry in nearly 100% for both usual and optimal conditions (*p*-value>0.05, Table 2). In contrast, participants with chronic stroke showed asymmetrical LLL-STS of the lower extremities, particularly in a usual condition, with the maximal LLL-STS in the affected and non-affected limb of 47% and 75% of their body weight, respectively (*p*-value<0.001). This resulted in their LLL-STS symmetry of approximately 62% (Table 2). However, these differences were significantly reduced when they attempted to take body weight onto both lower extremities equally (LLL-STS symmetry increased to 73%, *p*-value<0.001, Table 2).

Table 2 Amount of lower limb loading during sit-to-stand (LLL-STS) in usual and optimal condition of participants

Variable **Affected side**		Usual condition		*P*-value	Optimal condition		*P*-value	Loading symmetry		*P*-value
		Non-affected side		Affected side	Non-affected side		Usual condition	Optimal condition		
Healthy individuals (n=10)	Minimal LLL-STS*	3.57±2.39	2.84±2.26	0.02	3.56±2.10	3.15±2.19	0.05	79.55	88.48	0.14
	Maximal LLL-STS*	58.31±5.22	58.16±5.23	0.95	59.42±5.90	56.49±5.59	0.34	99.74	95.07	0.31
	Average LLL-STS*	37.60±3.89	37.84±6.12	0.90	38.67±4.82	37.37±5.73	0.49	99.37	96.63	0.96
	Duration (s)	3.28±0.46			3.57±0.33					0.40
Stroke participants (n=39)	Minimal LLL-STS*	6.58 ±2.77	4.48 ±3.30	0.001	6.96 ±2.52	4.24 ±3.36	<0.001	68.08	60.92	0.72
	Maximal LLL-STS*	47.02 ±11.92	75.41 ±12.16	<0.001	52.56 ±10.52	71.57 ±10.81	<0.001	62.35	73.43	<0.001
	Average LLL-STS*	29.35 ±9.05	48.46 ±10.67	<0.001	33.51 ±7.96	48.43 ±8.01	<0.001	67.04	69.19	0.05
	Duration (s)	7.32 ±2.84			8.22 ±3.39				0.01	

Note: The data are presented using mean ±SD, *are presented using percent of their body weight.
The differences between affected and non-affected side, usual and optimal condition were analyzed using paired samples t test.
Healthy individuals were presented for the non-dominant side (affected side), and dominant side (non-affected side).

Discussion

The study investigated the data relating to LLL-STS in usual and optimal conditions in ambulatory individuals with stroke as compared to the data from healthy individuals. The findings indicated that participants with stroke showed obvious asymmetrical LLL-STS as compared to those found in healthy individuals. However, these differences were significantly reduced when they were instructed to take body-weight onto both lower extremities equally (*p*-value<0.001, Table 2).

Engardt et al.[8] reported that individuals with stroke could take their body weight onto the affected limb of approximately 37% of their body-weight. Brunt et al. [9] also found that stroke patients increased LLL-STS on the non-affected limb for 16% of the body-weight. However, these data were derived from different studies that may not clearly reflect LLL-STS symmetry. The current findings demonstrated that the LLL-STS differences of the lower extremities were approximately 28% of their body-weight. This resulted in asymmetrical LLL-STS (approximately 62%, Table 2) that was clearly greater than that found during stepping (LLL of the affected limb was 91.61±7.33% of their body weight as compared to that found in healthy individuals of 94.20±4.64% of their body-weight)[13-14]. The researchers [14] also reported the differences of LLL during stepping in stroke individuals for 5% of their body-weight that resulted in lower limb support symmetry during stepping of 94.The mark differences in LLL-STS between the lower extremities as compared to the data found during stepping may confirm the high demand of STS for stroke individuals.Subsequently, the decreasing use of the affected limb during such task could introduce the effects of learn non-used including muscular atrophy and bone density loss that could retard motor recovery. On the contrary, the increasing use of the non-affected limb as a compensatory strategy could enhance effects of overuse such as musculoskeletal pain and joint degeneration that further affect mobility [15].

Nonetheless, the degree of asymmetry LLL-STS between the lower extremities could significantly reduce when the participants were instructed to optimally take their body weight onto both legs equally (Table 2). This movement modification was demonstrated even in the participants with post-stroke time of 41.97±21.23 months (Table 1) that suggested benefit of verbal commands and remaining capability inherent in individuals with stroke. After stroke, patients commonly have impaired intrinsic information mechanisms that distort their ability to control an optimal movement. Thus they retain some ability that they are unable to generate by their own determination. Augmented verbal feed-back plays a major role in helping the participants to become aware of how they perform, and correct any compensatory movements in order to optimize their movement control[16].Therefore, they showed significant improvement in their LLL-STS symmetry in an optimal condition (Table 2). Bach-Y-Rita and Kercel[17] indicated that the human movement system had a great capability to use alternative sources of input helping them to successfully carry out a required task. Then repetitive practice using verbal commands may promote functional ability of these individuals. The findings offer an alternative simple rehabilitation strategy that can be applied in various settings, such as hospital, clinical community and patients' home.

However, there are some limitations of the study. This study indicated participants at a chronic stage to clearly indicate effects of verbal command in those with less capability to be changed in their movement system. The cross-sectional data were unable to clearly indicate the importance of LLL-STS.Therefore, a further study that prospectively assesses the influence of asymmetrical LLL-STS on the occurrence of musculoskeletal injury and intervention study on the effects of verbal command for LLL-STS symmetry would strengthen the finding of this study.

Conclusion

Stroke individuals retained some capability that they did not usually access, even they had long post-stroke duration. The use of verbal commands could benefit LLL-STS symmetry of these individuals.

Take home messages

Ambulatory individuals with stroke could improve lower limb loading symmetry during sit-to-stand through verbal command. Thus, verbal command could be used to promote the use of retaining ability among individuals with stroke.

Conflicts of interest

The authors declare no conflict of interest.

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