Asymmetrical Lower Limb Support Ability of Ambulatory Patients with Stroke were Obviously Found during Performing a Challenging Task

ความไม่สมมาตรในการลงน้ำหนักของขาของผู้ป่วยโรคหลอดเลือดสมองที่เดินได้พบได้ชัดเจนขณะทำงานที่ท้าทาย

Panita Thamnithis (ปณิตา ธรรมนิธิศ)* Arunee Chanapisit (อรุณี ชนาภิสิทธิ)**

Pipatana Amatachaya (พิพัฒน์ อมตฉายา)*** Thiwabhorn Thaweewannakij (ทิวาพร ทวีวรรณกิจ)****

Punnee Peungsuwan (พรรณี ปึงสุวรรณ)***** Sugalya Amatachaya (สุกัลยา อมตฉายา)*****

ABSTRACT

Asymmetrical lower limb support ability (LLSA) following stroke likely documented during stepping activity due to its similarity to a walking task. However, the sit-to-stand (STS) is a basic but challenging functional activity in daily living, and there was no obvious evidence relating to LLSA symmetry during STS in these individuals. Therefore, this study assessed the levels of LLSA symmetry while performing STS and stepping in 20 participants with stroke who walked with and without a walking device using digital load cells. The findings indicated that participants with stroke exhibited asymmetrically lower limb loading while performing STS task (69.7% of body-weight) more obviously than that while executing stepping activity (93.9% of body-weight), especially in those who used a walking device. Thus the incorporation of rehabilitation strategies to promote LLSA symmetry during STS may benefit functional ability and safety in ambulatory patients with stroke.

บทคัดย่อ

ความไม่สมมาตรในการลงน้ำหนักของขาภายหลังการเป็นโรคหลอดเลือดสมองมักรายงานขณะก้าวขา เนื่องจากความคล้ายคลึงกับการเดิน อย่างไรก็ตาม การลุกขึ้นยืนถือเป็นกิจกรรมพื้นฐานแต่ท้าทายในชีวิตประจำวันและยังไม่มีหลักฐานชัดเจนเกี่ยวกับความสมมาตรในการลงน้ำหนักขณะลุกขึ้นยืนในผู้ป่วยกลุ่มนี้ ดังนั้น การศึกษานี้จึงประเมินระดับความสมมาตรในการลงน้ำหนักขณะลุกขึ้นยืนและก้าวขาในผู้ป่วยโรคหลอดเลือดสมองจำนวน 20 คนที่ใช้และไม่ใช้อุปกรณ์ช่วยเดินโดยใช้อุปกรณ์รับน้ำหนักแบบตัวเลข ผลการศึกษาพบความไม่สมมาตรในการลงน้ำหนักของขาของอาสาสมัครโรคหลอดเลือดสมองขณะลุกขึ้นยืน (ร้อยละ 69.7 ของน้ำหนักตัว) ชัดเจนมากกว่าขณะก้าวขา (ร้อยละ 93.9 ของน้ำหนักตัว) โดยเฉพาะอย่างยิ่งในอาสาสมัครที่เดินโดยใช้อุปกรณ์ช่วยเดิน ดังนั้น การใช้วิธีการฟื้นฟูความสามารถเพื่อส่งเสริมความสมมาตรในการลงน้ำหนักที่ขาขณะลุกขึ้นยืนจึงน่าจะเป็นประโยชน์ต่อระดับความสามารถและความปลอดภัยในผู้ป่วยโรคหลอดเลือดสมองที่เดินได้

Keywords: Cerebrovascular diseases, Lower limb function, Physical Therapy

คำสำคัญ: โรคหลอดเลือดสมอง การทำงานของขา กายภาพบำบัด

** Student, Master of Science Program in Physical Therapy, School of Physical therapy, Faculty of Associated Medical Sciences, Khon Kaen University*

*** Manager, Siam International Physiotherapy Clinic, Chonburi*

**** Associate Professor, Department of Electronics Engineering, Faculty of Engineering and Architecture, Rajamangala University of Technology Isan, Nakhon Ratchasima*

***** Lecturer, School of Physical therapy, Faculty of Associated Medical Sciences, Khon Kaen University*

****** Associate Professor, School of Physical therapy, Faculty of Associated Medical Sciences, Khon Kaen University*

Introduction

The unilateral sensorimotor impairments following stroke likely reduce ability of the patients to control movements of their affected limb (Duncan, 1994; Mercier et al., 2001). These impairments further distort ability of body-weight transferring between the legs and lower limb support ability (LLSA) of the affected leg (Wall et al., 1986; Adegoke et al., 2012). Therefore, the patients commonly exhibit asymmetrical LLSA that result in they walk asymmetrically (Patterson et al., 2008). Such walking manner has negative impacts for walking stability, energy expenditure, and risk of musculoskeletal disorders and falls that further affect levels of independence and quality of life of the patients (Hendrickson et al., 2014; Song, Park, 2015; Kim et al., 2016).

However, the existing evidence on both assessments and treatments relating to LLSA symmetry are usually emphasized on the problems while performing stepping due to its similarity to a walking task (Goldie et al., 1996; Jaffe et al., 2004; Park et al., 2016). On the contrary, sit-to-stand (STS) movement is a basic and pre-requisite ability for daily movements, but the task is biomechanically challenging for range of motion and lower limb joint torque greater than that for standing and stepping (Lomaglio, Eng, 2005; Kerr et al., 2016). Ability to complete the task also related to many factors such as muscle strength, co-ordination, balance ability, weight-bearing distribution, proprioception and psychological status associated with walking ability (Lord et al., 2002; Briere et al., 2010; Kerr et al., 2016). However, little evidence relating to LLSA symmetry while performing the STS task was seen. The researchers hypothesized that the high demand of STS ability resulted in ambulatory patients with stroke exhibits obvious asymmetrical LLSA as compared to that while stepping. The findings would suggest the modification of rehabilitation treatments for the ambulatory stroke patients.

Objective of the study

To investigate the level of LLSA symmetry while performing stepping and STS in ambulatory stroke patients. The data were reported for total participants and separately for those who walked with and without a walking device.

Methodology

Participants

This cross-sectional study was conducted in twenty ambulatory stroke patients from a tertiary rehabilitation center and several communities in Thailand. The inclusion were independent ambulatory patients with chronic stroke (post-stroke time more than 6 months) (Jaffe et al., 2004), and ages between 40 to 74 years old (Organisation for Economic Co-operation and Development [OECD], 2003; Thaweewannakij et al., 2016), who were able to rise from a chair with or without using their arms, and to walk independently over at least 10 meters with or without a walking device. The exclusion criteria were any conditions that may affect ambulatory ability or ability to participate in the study, such as auditory or visual deficits that were unable to be corrected by a hearing aid, glasses or contact lens; musculoskeletal pain with a pain scale more than 5 out of 10 on a visual analog scale (VAS) (Amatachaya et al., 2016); deformity in the limbs or spine that affect ambulatory ability; unstable cardiovascular, orthopedics, musculoskeletal, or neurological diseases other than stroke; and unable to follow a command used in the study. All participants understood and signed written informed consent documents that were approved by the ethics committee of Khon Kaen University (HE601351) before participation in the study.

Research Protocols

Participants were interviewed for personal data (including age, gender, and body mass index), stroke characteristics (including hemiplegic side, type of stroke, post-stroke time, and walking device used, if any). Then participants were assessed for LLSA while performing STS and stepping using a digital load cell (uncertainty= ±0.82 kg/side). Details of the tests are as follows.

- *Lower limb support ability during sit-to-stand*

Participants sat on a standard armless chair with hip flexion at 90 degrees, and the back upright against the backrest of the chair, and their feet placed flat on both digital load cells at about the hip width apart with the heels at 10 cm behind the knees (Khuna et al., 2017). Then they were instructed to stand up with the attempt to adequately control LLSA of each lower extremity as much as possible. Chou et al. (2003) reported normal LLSA of each leg during STS at 49.5%-50.5% of the body-weight with the best perfect LLSA symmetry during STS was 100% of the body-weight (Chou et al., 2003)

- *Lower limb support ability during stepping*

Participants were in a step standing position with placing the affected leg on a digital load cell and the non-affected leg slightly backward outside the load cell. Then they were instructed to adequately shift their body-weight onto the affected leg as much as possible and step the non-affected leg forward and backward. Then the LLSA of the non-affected leg was also assessed using the same protocols. Normal LLSA during a single limb support while stepping of each leg should be approximately 95%-100% of the body-weight and perfect LLSA symmetry during stepping was 100% of the body-weight (Goldie et al., 1996)

The LLSA assessments were performed over 5 trials, in which the first 2 trials were served as practice trials, and the average amount of maximum LLSA over the other 3 trials of each lower limb was used for data analysis. Then the level of LLSA symmetry was calculated using the formula (Kumprou et al., 2017).

$$\text{LLSA symmetry} = \frac{\text{average LLSA of the leg with lower value}}{\text{average LLSA of the leg with higher value}} \times 100$$

During the tests, participants had to fasten a light-weight safety belt around their waist with a physiotherapist always on their side to ensure the participant's safety and provided assistance as needed. They were able to take a period of rest as needed in order to minimize fatigue and muscle soreness during the tests.

Statistical analysis

Descriptive statistics were used to explain personal stroke characteristic and findings of the study. The dependent samples t-test was used to compare the amount of LLSA between the affected and non-affected leg of stroke participants. The independent samples t-test and chi-square test were used to compare demographics, stroke characteristics and findings of the study between those who walked with and without a walking device for the continuous and categorical data, respectively. A *p* value of less than 0.05 was considered as a level of statistical significance.

Results

Twenty ambulatory participants with stroke (walking with a walking device [n = 10] and without a walking device [n=10]) with an average age of 60 years old and body mass index of 24.5 kg/m^2 completed the study (Table 1). There were no significant differences of demographics and stroke characteristics between participants who walked with and without a walking device (p>0.05, Table 1).

Table 1 Demographics and stroke characteristics of participants

Variable	All stroke participants (n=20)	Stroke participants: Walked with a walking device (n=10)	Stroke participants: Walked without a walking device (n=10)
Age[a] (years)	59.6±8.3(56.2±63.3)	58.9±9.3 (53.2±64.9)	60.3±7.7 (55.4±65.3)
Body mass index[a] (Kg/m^2)	24.5±3.2(23.1±25.8)	24.4±3.5 (22.3±26.7)	24.6±3.2 (22.6±26.6)
Gender[b,c]: male, n(%)	10(50)	6(60)	4(40)
Hemiplegic side[b,c]: left ,n(%)	10(50)	6(60)	4(40)
Type of stroke[b,c]: ischemic, n(%)	15(75)	8(80)	7(70)

Note: [a] Data are presented using mean±standard deviation (95% confidence intervals), and the data comparisons between those who walked with and without a walking device were executed using the independent samples t-test.

[b] Data were presented using the number (%), and compared between those who walked with and without a walking devices using the chi-square test.

[c] These variables were categorized as follows; gender: male/female, hemiplegic side: left/right, type of stroke: ischemic/ hemorrhage.

The average LLSA of the affected leg was obviously lower than that of the non-affected leg, particularly for an STS task (Table 2). These differences resulted in the non-affected bore greater LLSA for approximately 19% of their body-weight while performed STS (p<0.01), and approximately 5% of their body-weight while executed a stepping activity (p<0.05). These differences also led to asymmetrical LLSA, especially for STS activity (approximately 70%). These differences and asymmetrical LLSA were obviously demonstrated in participants who walked with a walking device, whereas those who walked without a walking device showed no significant differences of LLSA during stepping (p>0.05, Table 2).

Table 2 Lower limb support ability during sit-to-stand and stepping in ambulatory participants with stroke who walked with and without a walking device

Variable	Lower limb support ability (LLSA)			LLSA symmetry
	Affected leg¥	Non-affected leg¥	Mean differences of LLSA¥	
All participants (n =20)				
During sit-to-stand	52.7±10.7 (48.0±57.0)	72.1±12.3 (67.3±77.7)	19.4±20.5** (0.9±8.2)	69.7±16.8 (62.4±76.7)
During stepping	93.7±9.9 (89.0±97.6)	98.3±4.2 (96.3±100.0)	4.6±7.7* (9.8±29.0)	93.9±7.0 (90.7±96.5)
Participants who used a walking device (n =10)				
During sit-to-stand	49.8±9.6 (44.7±56.0)	77.1±14.0 (68.6±85.0)	27.3±22.2** (11.4±43.1)	62.5±16.1 (54.3±72.1)
During stepping	91.0±10.5 (84.8±96.7)	97.6±5.1 (94.8±100.8)	6.6±7.4* (1.3±12.0)	92.6±7.6 (87.5±96.6)
Participants who did not use a walking device (n =10)				
During sit-to-stand	55.5±11.5 (48.4±62.0)	67.1±8.1 (62.5±71.8)	11.6±16.1* (0.0±23.2)	76.9±14.8 (68.1±84.8)
During stepping	96.4±9.1 (90.6±101.2)	98.9±3.3 (96.7±100.5)	2.5±7.8 (-3.0±8.1)	95.2±6.5 (90.8±98.0)

Note: The data are presented using mean ± standard deviation (95% confidence intervals), ¥ The data are presented as percent of their body-weight, **p-value* < 0.05, ***p-value* < 0.01

Discussion and conclusion

The study investigated the levels of LLSA symmetry while performing stepping and STS in ambulatory patients with stroke. The results indicated that the asymmetrical LLSA was obviously found, especially while they performed an STS task, (63%). On the contrary, the LLSA was not much different while performed a stepping activity (Table 2).

The LLSA reduction on affected leg that led to asymmetrical LLSA was influenced by unilateral sensorimotor impairments following stroke. The impairments resulted in the participants reduced ability to adequately control the affected limb; and thus they could bear LLSA on the affected limb only 53% of their body-weight while performing STS and 94% while executing the stepping (Table 2). The particular LLSA reduction was found in those who used a walking device because these individuals commonly had obvious sensorimotor deterioration (Betani, Maki, 2005). The use of a walking device also allowed individuals to increase compensation from the non-affected limb. Therefore, these individuals increasingly used the non-affected limb for 77% of their body-weight during STS, and 98% of their body-weight during stepping as compared to the affected limb (Table 2). The findings associated with those of Goldie et al. (1996) who found that stroke participants transferred less body weight on affected leg (65.5% of body-weight) than non-affected leg (85.0% of body-weight) in standing. Likewise, Chou et al. (2003) found that the LLSA of the affected limb was only 37.9% of body-weight while performing STS and mainly use on the non-affected leg (approximately 62.1% of body weight) to complete the task.

The obvious asymmetrical LLSA for the STS task might associate with the biomechanically demanding of the task that requiring lower extremity joint torque and range of motion greater than that of stepping (Lomaglio, Eng, 2005; Kerr et al., 2016). Apart from muscle strength, ability to complete STS was also correlated with sensation, balance and psychological status of individuals (Lord et al., 2002). Although the stepping activity was most similar to walking, the task requires individuals to control movements in a small range of motion. Such task might allow individuals to lock the knee that helped them to increase weight-bearing and showed minimal asymmetrical LLSA between the legs (Table 2). STS was a basic activity needed for many other daily tasks such as standing up from a chair, bed or toilet (Kerr et al., 2016). Continuing increased LLSA on the non-affected limb while executing the task could lead to musculoskeletal disorders such as pain and joint degeneration due to overuse, and musculoskeletal dystrophy such as the risk of bone mass density loss and muscle atrophy due to misuse that further distorted functional improvement of the participants (Hendrickson et al., 2014). On the contrary, the increased amount of lower limb loading could improve muscular activity, muscle co-contraction, bone mass density, and proprioceptive sensation that were essential for functional ability (Jiang et al., 2006; Carda et al., 2009). Therefore, the findings suggested the importance of rehabilitation strategies to promote LLSA during STS of these individuals.

However, some limitations of the study occurred. The study assessed amount of LLSA without clear evidence to support its importance using only 10 participants who walked with and without a walking device. Thus, a further study that would assesses factors relating to levels of asymmetrical LLSA and effects of rehabilitation strategy to promote symmetrical LLSA during executing a STS task might clearly support the importance of LLSA for these individuals.

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