J. Phys. Ther. Sci. 31: 992–996, 2019

The Journal of Physical Therapy Science

Original Article

Clinical assessment of motor imagery and physical function in mild stroke patients

Katsuya Sakai, RPT, MS[1)], Yumi Ikeda, RPT, PhD[1)*]

[1)] *Tokyo Metropolitan University Graduate School of Human Health Sciences: 7-2-10 Higashiogu, Arakawa-ku, Tokyo 116-8551, Japan*

Abstract. [Purpose] The aim of this study was to clarify whether the motor imagery of walking and physical function are related in mild hemiplegic stroke patients. [Participants and Methods] Sixteen mild hemiplegic stroke patients were included in this study. We evaluated motor imagery with a 10-m walking, the estimation error and the kinesthetic and visual imagery questionnaire. Physical function was evaluated with the actual 10-m walk test time, Brunnstrom recovery stage, stroke impairment assessment set, and functional independent measure. The correlation coefficient was calculated using Spearman's correlation coefficient for all evaluation methods. [Results] The 10-m walking motor imagery took an average of 23.36 ± 22.14 s. The actual 10-m walk test averaged 24.87 ± 21.41 s. The 10-m walking motor imagery and the 10-m walking speed were significantly correlated. There was a significant correlation between the 10-m walking motor imagery and the Brunnstrom recovery stage, stroke impairment assessment set, and functional independent measure. There were no significant correlations between the estimation error and all the assessments. [Conclusion] These results show that the motor imagery of walking is related to physical function in mild hemiplegic stroke patients.

Key words: Motor imagery, Estimation error, Mild hemiplegic stroke patients

(This article was submitted Jul. 11, 2019, and was accepted Sep. 19, 2019)

INTRODUCTION

Motor imagery is the process of simulating movement internally before expressing the actual movement[1, 2)]. A large number of studies have reported that the area of brain activity of motor imagery and the area of actual motor execution overlap[3, 4)]. Indicators that clinically evaluate these motor imagery abilities include the movement imagery questionnaire[5)], the kinematics and visual imagery questionnaire (KVIQ)[6)], mental chronometry (MC)[7)], and mental rotation[8)]. These indicators are used to evaluate the ability of various participants to perform motor imagery[9–11)]. It has also been reported that in stroke patients motor imagery abilities are reduced compared with that in healthy individuals[12–14)].

Furthermore, it has been reported that the motor imagery time of movement is similar to the movement execution time[15)]. The motor imagery and execution time of walking are similar in hemiplegic stroke patients, and it is also clear that both the motor imagery time and the execution time of walking are slower compared to that in healthy individuals[16)]. In previous research, it has been hypothesized that if mild hemiplegic stroke patients who are able to walk have similar motor imagery and execution times, their motor imagery ability may be related to their physical functions that constitute the ability to walk.

Some previous studies have also reported on the estimation error difference between the motor imagery time and the execution time[17, 18)]. It has been stated that a patient's estimation error is also related to physical function in Parkinson's disease[19)].

We hypothesize that the motor imagery time of walking and the walking time are similar. We also hypothesize that motor imagery and estimation error are related to the severity of paralysis, sensory disturbance, and activities of daily living.

*Corresponding author. Yumi Ikeda (E-mail: ikedayum@tmu.ac.jp)

The purpose of this study is to clarify whether the motor imagery of walking and estimation error are related to the physical function in mild hemiplegic stroke patients who are able to walk.

PARTICIPANTS AND METHODS

The participants were 16 sub-acute hemiplegic stroke patients with an average age of 59.2 (± 14.7 years). Time since stroke was 75.3 (± 40.9 days). There were 11 patients with left hemiplegia, and the average mini mental state examination score was 27.3 points (± 3.2). Inclusion criteria were mild stroke patients who were able to walk at the time of the study.

This study was conducted with the approval of the Hatsudai Rehabilitation Hospital Ethics Committee (approval number: H28 −42). Furthermore, according to the Helsinki Declaration and ethical guidelines for medical research aimed at humans, this research was thoroughly explained to the study participants and implemented after written and signed consent was obtained.

The evaluation of motor imagery involved analyzing the 10 m walking motor imagery and the vividness of the motor imagery. The evaluation of physical functions was 10 m walking speed and the Brunnstrom recovery stage (BRS), the stroke impairment assessment set (SIAS), and the functional independence measure (FIM). To verify whether the 10 m walking motor imagery and the actual 10 m walking speed are related to physical functions, the value obtained by dividing the value of 10 m walking speed by the 10 m walking motor imagery was taken as the estimation error.

To determine the 10 m walking motor imagery, we asked the participants to imagine standing in front of a walking path of 10 m and to then imagine walking at a comfortable speed to a position 10 m ahead. The participants were given a stopwatch to measure the time it took them. The exercise and the measurement were performed twice, and the average value was calculated.

The vividness of the motor imagery was determined by using the KVIQ-10[6].

The measurement of the actual 10 m walking speed was performed on a 10 m straight walking path. The participants were instructed to maintain a comfortable walking speed. The walking speed was measured twice, and the average value was calculated.

Both BRS and SIAS are integrated assessments used to quantify stroke-related dysfunction. The SIAS is divided into nine types of functional disorders and consists of 22 items[20]. This study uses the SIAS to determine whether the degree of paralysis in the lower extremities—including function and sensory disturbance—are related to the motor imagery of walking. The elements used are hip-flexion test, knee-extension test, foot-pat test, lower limb light touch, and lower limb position. The total scores of these elements were used for this study.

The correlation coefficient was calculated between the average value of 10 m walking speed and each outcome of the analysis methods mentioned above using the Spearman correlation coefficient. This served to determine whether there is a correlation between the average value of the 10 m walking motor imagery and the average value of 10 m actual walking speed. Furthermore, we also calculated whether there is a correlation between the estimation error and each of the evaluation outcomes. For statistical analysis, the significance level was set at 5%.

RESULTS

The results of the assessments and the correlation coefficient analysis are shown in Tables 1 and 2 respectively.

The 10 m walking motor imagery and 10 m walking had a significant positive correlation (ρ=0.96, p<0.00). There was also a significant correlation between the 10 m walking speed and the BRS values for upper limb, fingers, and lower limbs, the SIAS hip-flexion test, the knee-extension test, the foot-pat test, the lower limb light touch, the lower limb position and total points, and the Motor-FIM, Cognitive-FIM, and total FIM scores. The 10 m walking motor imagery was also significantly correlated to all of these values. Furthermore, there was a significant negative correlation between KVIQ-10—an evaluation of the vividness of motor imageries—and the 10 m walking motor imagery (ρ= −0.68, p<0.00). There were no significant correlations between the estimation error and the various evaluations.

DISCUSSION

This study analyzed whether the 10 m walking motor imagery correlated with the physical functions of mild hemiplegic stroke patients who are able to walk. The results showed a significant correlation between physical 10 m walking speed and the 10 m walking motor imagery, between the 10 m walking speed and the different assessment outcomes, and between the 10 m walking motor imagery and the assessment outcomes.

In the previous research, walking speed has been reported to be correlated with the severity of patients' paralysis, sensory disturbance, and activities of daily living[21–23]. In this study, the walking speed is also significantly correlated with the outcomes of the BRS, SIAS, and FIM measures, supporting the results of previous studies.

With regard to the motor imagery of walking, it has been reported that the same brain region is active at the time of imaging than at execution[3]. It has also been previously reported that practicing motor imagery promotes functional recovery[4]. However, reports on the relationship between imageries of movement such as walking and physical functions have

Table 1. Results of motor imagery and physical function measures

BRS upper limb	3.5 (3–5)
BRS finger	3.5 (2.75–4)
BRS lower limb	4 (3–5)
SIAS hip-flexion test (points)	4 (3–4)
SIAS knee-extension test (points)	3 (3–4)
SIAS foot-pat test (points)	1.5 (0–4)
SIAS lower limb light touch (points)	2.5 (1.75–3)
SIAS lower limb position (points)	2 (1.75–3)
SIAS total (points)	51.0 ± 14.5
Motor-FIM (points)	71.8 ± 14.8
Cognitive-FIM (points)	30.1 ± 5.1
FIM total (points)	102.0 ± 18.9
10 m gait speed (sec)	24.87 ± 21.41
Image 10 m gait speed (sec)	23.44 ± 21.09
Estimation error (sec)	1.51 ± 6.19
KVIQ-visual (points)	33.4 ± 8.7
KVIQ-kinesthetic (points)	30.4 ± 9.4
KVIQ total (points)	63.8 ± 18.7

BRS: Brunnstrom recovery stage; SIAS: Stroke impairment assessment set; FIM: Functional independence measure; KVIQ: Kinesthetic and visual imagery questionnaire.

been intermittent and varied. The results clarified that the 10 m walking motor imagery is highly correlated with the actual walking speed and is also correlated with the severity of paralysis and activities of daily living, which is consistent with our hypothesis. Furthermore, there are existing reports on the association between sensory disturbances and motor imagery of walking. Liepert et al. reported on the motor imagery ability evaluated by the MC task in hemiplegic stroke patients, stating that those with severe sensory disturbance have lower motor imagery ability compared with those with mild sensory disturbance or healthy individuals[24]. The results showed that there is a correlation between the motor imagery of walking and sensory disturbance. This indicates that sensory disturbance may also affect the motor imagery of movement, resulting in new views of motor imagery evaluation and sensory disturbance. Furthermore, there is a negative correlation between 10 m walking speed and KVIQ-10, a test that evaluates the vividness of motor imagery. Furthermore, KVIQ-10 is positively correlated with the severity of the individuals' paralysis, sensory impairment, and FIM. This indicates that the clearer the motor imagery, the higher the walking ability and physical function. To our knowledge, there has thus far been no research findings concerning the relationship between the vividness of the motor imagery and physical function, meaning that this study can be considered to be significant.

Regarding individuals' estimation errors, it has been reported that for healthy elderly individuals and patients suffering from Parkinson's disease, dissociation of motor imagery and execution time is related to physical functions[17, 25]. However, the results showed no correlation between estimation error and physical functions. The participants in this study were individuals who could walk unassisted, and most participants had relatively mild paralysis. Mild stroke patients who are able to walk were highly correlated with motor imagery and actual execution time. The estimation error was therefore small and not related to physical functions.

The limitations of this study include the lack of control data of healthy individuals, the small number of participants. In the future, we will compare participants' data with control data, increase the number of participants, and further clarify the relationship between motor imagery and physical functions. In this research, the correlation between the motor imagery of walking and actual walking speed and physical functions means that the image specific to a certain movement can also be an index reflecting physical functions.

Conflict of interest

The authors have no conflicts of interest to declare for this research.

ACKNOWLEDGMENT

We would like to thank the Hatsudai Rehabilitation Hospital for their assistance in the measurements for this study.

Table 2. The correlation coefficient of motor imagery and physical functions

	10 m gait	Image 10 m gait	estimation error	KVIQ visual	KVIQ kenesthetic	KVIQ total	BRS upper	BRS finger	BRS lower	SIAS hip flexion test	SIAS knee extension test	SIAS foot pat test	SIAS light touch	SIAS position	SIAS total	FIM motor	FIM cognition	FIM total
10 m gait	1.00	0.96**	0.02	−0.65*	−0.67**	−0.68*	−0.60*	−0.51*	−0.65*	−0.88**	−0.83**	−0.67**	−0.52*	−0.56*	−0.77**	−0.82**	−0.65**	−0.81**
Image 10 m gait		1.00	−0.26	−0.62*	−0.60*	−0.62*	−0.61*	−0.52*	−0.68**	−0.82**	−0.75**	−0.65**	−0.53*	−0.53*	−0.71**	−0.84**	−0.73**	−0.85**
Estimation error			1.00	−0.05	−0.17	−0.11	0.08	0.10	0.16	−0.09	−0.19	0.01	0.09	−0.08	−0.10	0.18	0.38	0.23
KVIQ visual				1.00	0.91**	0.98**	0.54*	0.46	0.28	0.63**	0.52*	0.41	0.50*	0.46	0.48	0.62*	0.40	0.59*
KVIQ kenesthetic					1.00	0.98**	0.42	0.36	0.26	0.69**	0.55*	0.39	0.63**	0.61*	0.48	0.51	0.33	0.48
KVIQ total						1.00	0.49	0.42	0.28	0.68**	0.55*	0.41	0.58*	0.55*	0.49	0.58*	0.37	0.55*
BRS upper limb							1.00	0.94**	0.61*	0.65**	0.64**	0.66**	0.39	0.30	0.75**	0.65**	0.31	0.58*
BRS finger								1.00	0.60*	0.62*	0.60*	0.56*	0.37	0.24	0.70**	0.58*	0.24	0.51
BRS lower limb									1.00	0.75**	0.76**	0.89**	0.16	0.29	0.76**	0.59*	0.37	0.56*
SIAS hip flexion test										1.00	0.87**	0.75**	0.59*	0.68**	0.90**	0.68**	0.47	0.65**
SIAS knee extension test											1.00	0.72**	0.42	0.50*	0.82**	0.65**	0.28	0.58*
SIAS foot pat test												1.00	0.17	0.39	0.84**	0.69**	0.42	0.65**
SIAS light touch													1.00	0.90**	0.49	0.34	0.21	0.31
SIAS position														1.00	0.64*	0.37	0.20	0.33
SIAS total															1.00	0.67**	0.31	0.60*
FIM motor																1.00	0.76**	0.99**
FIM cognition																	1.00	0.86**
FIM total																		1.00

**p<0.01, *p<0.05.
BRS: Brunnstrom recovery stage; SIAS: Stroke impairment assessment set; FIM: Functional independence measure; KVIQ: Kinesthetic and visual imagery questionnaire

REFERENCES

1) Jeannerod M: The representing brain: neural correlates of motor intention and imagery. Behav Brain Sci, 1994, 17: 187–202. [CrossRef]
2) Decety J: The neurophysiological basis of motor imagery. Behav Brain Res, 1996, 77: 45–52. [Medline] [CrossRef]
3) Hétu S, Grégoire M, Saimpont A, et al.: The neural network of motor imagery: an ALE meta-analysis. Neurosci Biobehav Rev, 2013, 37: 930–949. [Medline] [CrossRef]
4) García Carrasco D, Aboitiz Cantalapiedra J: Effectiveness of motor imagery or mental practice in functional recovery after stroke: a systematic review. Neurologia, 2016, 31: 43–52. [Medline]
5) Hall C, Pongrac J, Buckholz E: The measurement of imagery ability. Hum Mov Sci, 1985, 4: 107–118. [CrossRef]
6) Malouin F, Richards CL, Jackson PL, et al.: The Kinesthetic and Visual Imagery Questionnaire (KVIQ) for assessing motor imagery in persons with physical disabilities: a reliability and construct validity study. J Neurol Phys Ther, 2007, 31: 20–29. [Medline] [CrossRef]
7) Decety J, Jeannerod M, Prablanc C: The timing of mentally represented actions. Behav Brain Res, 1989, 34: 35–42. [Medline] [CrossRef]
8) Parsons LM: Temporal and kinematic properties of motor behavior reflected in mentally simulated action. J Exp Psychol Hum Percept Perform, 1994, 20: 709–730. [Medline] [CrossRef]
9) Malouin F, Richards CL, Durand A: Normal aging and motor imagery vividness: implications for mental practice training in rehabilitation. Arch Phys Med Rehabil, 2010, 91: 1122–1127. [Medline] [CrossRef]
10) Kobelt M, Wirth B, Schuster-Amft C: Muscle activation during grasping with and without motor imagery in healthy volunteers and patients after stroke or with Parkinson's disease. Front Psychol, 2018, 9: 597. [Medline] [CrossRef]
11) Malouin F, Richards CL, Durand A, et al.: Effects of practice, visual loss, limb amputation, and disuse on motor imagery vividness. Neurorehabil Neural Repair, 2009, 23: 449–463. [Medline] [CrossRef]
12) de Vries S, Tepper M, Otten B, et al.: Recovery of motor imagery ability in stroke patients. Rehabil Res Pract, 2011, 2011: 283840. [Medline]
13) Feenstra W, Tepper M, Boonstra AM, et al.: Recovery of motor imagery ability in the first year after stroke. Int J Rehabil Res, 2016, 39: 171–175. [Medline] [CrossRef]
14) Malouin F, Richards CL, Durand A, et al.: Clinical assessment of motor imagery after stroke. Neurorehabil Neural Repair, 2008, 22: 330–340. [Medline] [CrossRef]
15) Saimpont A, Malouin F, Tousignant B, et al.: The influence of body configuration on motor imagery of walking in younger and older adults. Neuroscience, 2012, 222: 49–57. [Medline] [CrossRef]
16) Geiger M, Bonnyaud C, Bussel B, et al.: Assessing of imagined and real expanded Timed Up and Go tests in patients with chronic stroke: a case-control study. J Rehabil Med, 2018, 50: 413–419. [Medline] [CrossRef]
17) Sakurai R, Fujiwara Y, Yasunaga M, et al.: Older adults with fear of falling show deficits in motor imagery of gait. J Nutr Health Aging, 2017, 21: 721–726. [Medline] [CrossRef]
18) Beauchet O, Launay CP, Sejdić E, et al.: Motor imagery of gait: a new way to detect mild cognitive impairment? J Neuroeng Rehabil, 2014, 11: 66. [Medline] [CrossRef]
19) Ryckewaert G, Luyat M, Rambour M, et al.: Self-perceived and actual ability in the functional reach test in patients with Parkinson's disease. Neurosci Lett, 2015, 589: 181–184. [Medline] [CrossRef]
20) Liu M, Tsuji T, Tsujiuchi K, et al.: Comorbidities in stroke patients as assessed with a newly developed comorbidity scale. Am J Phys Med Rehabil, 1999, 78: 416–424. [Medline] [CrossRef]
21) Liu M, Chino N, Tuji T, et al.: Psychometric properties of the stroke impairment assessment set (SIAS). Neurorehabil Neural Repair, 2002, 16: 339–351. [Medline] [CrossRef]
22) Lin SI: Motor function and joint position sense in relation to gait performance in chronic stroke patients. Arch Phys Med Rehabil, 2005, 86: 197–203. [Medline] [CrossRef]
23) Khanittanuphong P, Tipchatyotin S: Correlation of the gait speed with the quality of life and the quality of life classified according to speed-based community ambulation in Thai stroke survivors. NeuroRehabilitation, 2017, 41: 135–141. [Medline] [CrossRef]
24) Liepert J, Büsching I, Sehle A, et al.: Mental chronometry and mental rotation abilities in stroke patients with different degrees of sensory deficit. Restor Neurol Neurosci, 2016, 34: 907–914. [Medline]
25) Kawasaki T, Mikami K, Kamo T, et al.: Motor planning error in Parkinson's disease and its clinical correlates. PLoS One, 2018, 13: e0202228. [Medline] [CrossRef]