Weight Bearing of the Affected Leg in Early Recovery of Walking Ability after Acute Stroke

Inuki, Hiroshi
Hidaka, Masami
Yoneda, Yukihiro
Shimada, Tomoaki

(Citation)
Bulletin of health sciences Kobe,22:39-46

(Issue Date)
2006

(Resource Type)
departmental bulletin paper

(Version)
Version of Record

(JaLCDOI)
https://doi.org/10.24546/81000707

(URL)
https://hdl.handle.net/20.500.14094/81000707

Weight Bearing of the Affected Leg in Early Recovery of Walking Ability after Acute Stroke

Hiroshi Inuki, RPT, MS[1,4] Masami Hidaka, RPT, Med, PhD[2]
Yukihiro Yoneda, MD, PhD[3] Tomoaki Shimada, RPT, PhD[5]

To find an indicator of early recovery of walking ability after disabling stroke, we evaluated the role of weight bearing of the affected leg at acute phase of stroke. Participants were 40 patients with a first-ever acute hemiplegic stroke. Using a stabilometer with two force footplates, we measured weight bearing rates between affected and unaffected legs at initial standing and over the next 3 weeks. According to walking ability at 1 month after stroke, participants were divided into 2 groups; (1) independent gait group (n=20) with Functional Independence Measure (FIM) score of 6 and 7, and (2) dependent gait group (n=20) with FIM of 1 to 5. Weight bearing rates of the affected leg at initial standing were significantly higher in the independent gait group than in the dependent gait group (average 41% and 27%; $p<0.001$), and they remained significantly higher in the independent gait group over the next 3 weeks ($p<0.001$). Although time from stroke onset to initial standing was not different between the 2 groups (average 10 and 13 days; $p=0.065$), time to initial walking exercise was shorter in the independent gait group (average 12 and 16 days; $p=0.047$). The weight bearing rates of the affected leg were well correlated with clinical parameters including the Brunnstrom's motor recovery stage and Barthel Index. Weight bearing measurement may be a good objective indicator of early gait independency after acute stroke.

Key words
Stroke, Weight bearing, Gait, Walk.

1 Department of Rehabilitation Medicine, Hyogo Brain and Heart Center
2 Department of Physical Therapy, School of Health Science, KIBI International University
3 Division of Neurology, Kobe Red Cross Hospital
4 Division of Health Sciences, Kobe University Graduate School of Medicine
5 Faculty of Health Sciences, Kobe University School of Medicine

INTRODUCTION

In Japan, a rapid growth of aging society and a recessionary financial condition have urged the major reform of healthcare systems. The recent medical changes include a shortening of acute hospitalization, which may have an impact on reduction of medical expenditure [1]. The role sharing of each hospital among acute phase, recovery phase, and maintenance phase, has become clearer. Hospitals specializing acute treatments such as our medical center need shorter hospitalization, but stroke patients have a relatively long hospitalization of approximately 1 month stay [2]. Although stroke patients receive acute and partially subacute treatments in acute care hospitals in Japan, early intensive rehabilitation is important to improve their lost abilities as early as possible.

In clinical rehabilitation practice, it is important to find a reliable indicator of early recovery of independent standing and walking after acute disabling stroke. Standing ability is a basic element and a preliminary step to walking. In patients with disabling stroke, the ability to bear their weight on the affected leg is one of the key factors that reflect standing ability in the acute phase of stroke. In activities of daily living (ADL), moreover, weight bearing on legs in standing position is a primary important factor for motor function of rising from a chair, shifting, walking, changing directions, and walking up and down the stairs [3]. Balance is a key ability to maintain posture and consists of three factors such as steadiness, symmetry, and dynamic stability [4]. Steadiness refers to the ability to maintain posture with minimal extraneous movement (sway). Symmetry is the ability to bear weight equally on both limbs in the standing position. Finally, dynamic stability refers to the ability to shift the center of gravity on the base of support without losing balance [4, 5].

Previous studies reported that majority of patients with a hemiplegic stroke bore their weight on both legs unequally during static task of quiet standing [3, 6-15]. In most studies, participants were patients at sub-acute phase [16] or chronic phase of several years after stroke onset [3, 6, 8, 9]. A few studies examined the weight bearing for stroke patients at acute phase of about one week after onset, but they did not examine a relationship between weight bearing and clinical outcomes [10, 11].

In this study, we evaluated the role of weight bearing in early recovery of motor function including standing and walking abilities in patients with acute stroke shortly after onset, and examined serially.

METHODS

Participants

All participants were acute stroke patients who were hospitalized at the Hyogo Brain and Heart Center, specializing acute treatments for cerebrovascular and cardiovascular diseases [2]. A total of 40 patients with acute stroke were recruited with the following criteria; (1) a first-ever acute hemiplegic stroke, (2) physiotherapy (PT) initiated shortly after stroke onset, and (3) no significant concomitant disorders interfering with PT and study protocol, such as unconsciousness, severe aphasia, dementia, musculoskeletal diseases, or other serious systemic disorders. All participants gave their in-

Table 1. Participant characteristics

Number of patients	40
Age (years)	65.0 ± 9.9 (36-81)
Gender (male/female)	22/18
Height (cm)	159.0 ± 10.1 (143-180)
Weight (kg)	59.2 ± 11.2 (41-89)
Stroke type (infarction/hemorrhage)	27/13
Hemiparetic side (left/right)	19/21
Time from stroke to initial physiotherapy (days)	6.2 ± 3.5 (1-15)
Time from stroke to initial standing (days)	11.6 ± 5.5 (3-31)

Date are mean ± SD (standard deviation) with range in parenthesis.

formed consent for the study protocol.

The characteristics of 40 participants were presented in table 1. At initial assessment by a physiotherapist, 8 patients had orthoses with both walking aids and physiotherapist assistances, 19 patients had minor gait assistances by physiotherapists and remaining 13 patients were supervised to walk independently by physiotherapists, when walking along parallel bars. During the study period of 3 weeks after initial standing, all participants received routine PT five times a week for 20-40 minutes per session in accordance with systemic conditions. PT included range of motion exercises for paralyzed side, neuromuscular re-education, sitting position, standing position, and gait training in accordance with the motor function and ADL level of each patient.

Weight bearing measurement

A stabilometer (Gravicorder G6100, Anima, Japan) was used to measure the weight bearing (figure 1). This system consists of two force footplates. The weight bearing data were loaded into a personal computer (NEC, Japan) through an A/D converter at a 50 Hz sampling rate, and were analyzed using software supplied with the system.

The participants, with eyes opened and looking straight forward, were verbally asked to keep a quiet standing for at least one minute on the force footplates. Their both legs were positioned at the width of pelvis, and their unaffected arms touched lightly on parallel bars under supervision of a physiotherapist. During one minute standing position, the participants were repeatedly asked to keep bearing their weight on both legs as equally as possible.

The weight bearing rates were calculated as an average value of weight supported in 15, 30, and 45 seconds, while maintaining a quiet standing position for one minute. The weight bearing measurements were repeated 4 times (initial standing, 1 week, 2 weeks and 3 weeks later).

Clinical and functional assessments

Clinical and functional assessments include the motor function according to the Brunnstrom's motor recovery stage (BRS) [17], sensory function with superficial and deep sensations, Barthel index (BI) [18], and Functional independence measure (FIM) [19]. Sensory function was graded into four stages; normal sensation, slight, moderate, and severe obtundation in four extremities. The BRS was graded into six stages; I) flaccid paralysis, II) increased muscle tone without active movement, III) increased muscle tone with active movements mainly in rigid extension synergy, IV) increased muscle tone with alternating gross movements in extension and flexion synergies, V) muscle tone normalization with some degree of selective muscle control, and VI)

Figure 1. Weight bearing measurement (Gravicorder G6100, Anima, Japan)
The participant stands quietly for one minute on the force footplates, with eyes opened, looking straight forward, unaffected arm touching lightly on parallel bar, both legs positioning a width of the pelvis. The weight bearing rates between affected and unaffected legs were measured.

normal muscle tone and control.

Statistical analysis

According to the functional outcome as measured by the FIM at one month after stroke onset, participants were divided into two groups; (1) independent gait group with FIM of 6 and 7, and (2) dependent gait group with FIM of 1 to 5.

The weighted bearing rates of the affected leg in all 40 participants were distributed normally at each 4 measurement on the one-sample t test. Accordingly, the comparisons between independent gait group and dependent gait group were analyzed using unpaired t test on continuous variables, chi-square test on categorical variables, and Mann-Whitney U test on ordinal variables. The serial measurements were analyzed using repeated-measures analysis of variance (ANOVA) with post-hoc Turkey's test. The correlations between clinical parameters and weight bearing rates of the

Table 2. Comparisons between independent and dependent gait groups

	Walking ability at one month		
	Independent n=20	Dependent n=20	p value
Age (years)	62.6 ± 10.7 (36-81)	67.5 ± 8.6 (48-80)	0.115[a]
Gender (male/female)	13/7	9/11	0.204[b]
Height (cm)	160 ± 10	158 ± 11	0.519[a]
Weight (kg)	62 ± 12	57 ± 10	0.161[a]
Stroke type (infarction/hemorrhage)	12/8	15/5	0.311[b]
Hemiparetic side (left/right)	8/12	11/9	0.343[b]
Time from stroke			
to initial PT (days)	5.7 ± 3.4 (1-12)	6.8 ± 3.7 (2-15)	0.276[c]
to initial standing (days)	10.0 ± 5.4 (3-22)	13.3 ± 5.1 (8-31)	0.065[c]
to initial walking exercise (days)	11.8 ± 5.8 (3-24)	15.6 ± 5.4 (9-32)	0.047[c]
Sensory (normal/slight/moderate/severe)			
Superficial	12/5/1/2	6/8/5/1	0.128[b]
Deep	15/5/0/0	14/4/2/0	0.342[b]
BRS (I/II/III/IV/V/VI)			
Initial standing	0/2/5/8/4/1	7/2/3/5/1/0	0.062[b]
3 weeks	0/0/0/0/7/13	0/1/6/6/6/1	0.001[b]
Barthel Index			
3 weeks (median)	95 (85-100)	57.5 (35-85)	0.001[c]
Weight bearing rate (%)			
Initial standing	41.0 ± 11.2 (16-56)	26.6 ± 13.9 (6-46)	0.001[a]
3 weeks	49.1 ± 4.0 (42-55)	37.1 ± 13.4 (9-53)	0.001[a]

Data are mean ± SD (standard deviation) with range in parenthesis.
The unpaired t test [a] was computed on continuous variables, the chi-square test [b] on categorical variables, and Mann-Whitney U test c on ordinal variables.
PT; Physiotherapy, BRS; Brunnstrom's motor recovery stage

affected leg were analyzed using Spearman Rank Correlation test. The statistical analyses were computed on the StatView version 5.0 (SAS Inc, USA). Statistical significance was set at less than 5%.

RESULTS

At one month after stroke onset, 20 participants regained an independent gait and the remaining 20 participants remained a dependent gait.

Table 2 shows the comparisons between independent gait group (n=20) and dependent gait group (n=20) (table 2). The weight bearing rates of the affected leg at initial quiet standing were significantly higher in the independent gait group than in the dependent gait group (average 41.0% and 26.6%; $p<0.001$; unpaired t test), although time from stroke onset to initial standing was not statistically different between independent gait group and dependent gait group (average 10.0 days and. 13.3 days; $p=0.065$; Mann-Whitney U test). Time from stroke onset to initial walking exercise was shorter in the independent gait group (average 11.8 days and 15.6 days; $p=0.047$; Mann-Whitney U test). At 3 weeks after initial standing, weight bearing rates of the affected leg were also significantly higher in the independent gait group than in the dependent gait group (average 49.1% and 37.1%, $p<0.001$; unpaired t test). The BRS and BI were significantly better in the independent gait group than in the dependent gait group. Other variables were not different between the 2 groups.

The weight bearing rates of the affected leg were significantly correlated with motor functions as measured by the BRS grade both at initial standing ($r=0.704$, $p<0.001$; Spearman Rank Correlation test) and at 3 weeks later ($r=0.621$, $p<0.001$; Spearman Rank Correlation test). They were also significantly correlated with BI scores at 3 weeks after initial standing ($r=0.568$, $p<0.001$; Spearman Rank Correlation test), but they were not correlated with sensory functions of both superficial and deep sensations.

The weight bearing rates of the affected leg were significantly higher over the 4 measurements (initial standing, 1 week, 2 weeks, and 3 weeks later) in the independent gait group than in the dependent gait group ($p<0.001$; Repeated-measures ANOVA) (table 3 & figure 2).

DISCUSSION

In this study, weight bearing rates of the affected leg at initial quiet standing position shortly after stroke onset were significantly higher in patients with early recovery of independent walking. Other factors including age, gender, stroke type, lesion side, or motor function as measured by the BRS grade, were not different between independent gait group and dependent gait group at the initial assessment. Furthermore, the weight bearing rates were consistently higher in patients with early recovery of independent walking over the 3 weeks after initial standing. The results suggest that weight bearing measurement is a good indicator of early favorable functional outcome with recovery of independent walking.

As shown in figure 2, however, the weight bearing rates of affected leg had a wide variation in both groups, being considerable overlap between individuals with early gait independency and those with gait dependency. Therefore, the measurements can not be a reliable method to differentiate the 2 groups clearly.

Previous studies reported that majority (79-87%) of patients with a hemiplegic stroke have bore their weight on both limbs unequally during quiet standing[6, 7]. The weight bearing rates of the affected leg have decreased 28 to 47% during standing after stroke [3, 6-15]. Furthermore, the asymmetry rates were well associated with affected leg muscle power [20, 21], standing ability [21], or ADL [6]. However, most studies examined the weight bearing in chronic stroke patients of a few years after onset [3, 6, 8, 9]. In contrast, we performed an initial weight bearing measurement at acute phase of a few days after stroke onset. A few studies examined the weight bearing in patients at acute phase of about one week after stroke onset [10, 11], but they did not examine a relationship between weight bearing and clinical outcomes. In this study examining acute stroke patients, the weight bearing rates of the affected leg were associated with motor and functional parameters as measured by the BRS grade and BI. This suggests that the weight bearing rate can be an indicator of global functional recovery beyond walking ability.

The limitation of this study is patient selection. In this study, we recruited selected patients who could stand independently or with mild assistance shortly after stroke onset. We excluded acute stroke patients with unconsciousness or dementia, because the weight bearing rate could not be measured properly in those patients. But such patients may recover to walk independently even during acute phase of stroke. Therefore, the weight bearing measurement is not generalizable to any stroke patients at present. To broaden an applicability of weight bearing measurement, a technical improvement will be necessary.

It may be impossible to rule out some bias of weight bearing measurement in this study. In the measurement, all participants actually stood with their unaffected arm touching lightly on parallel bar during one minute standing position, although they were repeatedly

Table 3. Time course of weight bearing rate of the affected leg

	Weight Bearing Rate (%)				
	Initial standing	1 week	2 weeks	3 weeks	p value
Age, years					0.161
< 65 (n=21)	30.3 ± 15.5	35.7 ± 15.2	37.7 ± 14.5	42.1 ± 11.2	
< 65 (n=19)	37.6 ± 12.4	41.8 ± 12.7	44.3 ± 12.8	44.2 ± 12.1	
Gender					0.176
Male (n=22)	35.4 ± 13.1	40.5 ± 11.8	44.5 ± 11.6	45.6 ± 9.0	
Female (n=18)	31.9 ± 16.0	36.3 ± 16.8	36.3 ± 15.5	40.0 ± 13.6	
Hemiparetic side					0.679
Left (n=19)	35.1 ± 14.4	39.7 ± 15.1	41.0 ± 13.1	44.0 ± 7.8	
Right (n=21)	32.6 ± 14.7	37.6 ± 13.8	40.7 ± 15.0	42.3 ± 14.2	
Type of stroke					0.660
Infarction (n=27)	35.6 ± 14.4	38.6 ± 14.9	41.8 ± 14.2	42.7 ± 11.6	
Hemorrhage (n=13)	30.0 ± 14.2	38.5 ± 13.4	38.8 ± 13.6	44.0 ± 11.6	
Walking ability at one month					0.001
Independent (n=20)	41.0 ± 11.2*	46.1 ± 8.5*	47.8 ± 6.7*	49.1 ± 4.0**	
Dependent (n=20)	26.6 ± 13.9	31.1 ± 15.1	33.9 ± 15.9	37.1 ± 13.4	

Data are mean ± SD (standard deviation).
The analysis of serial measurements was computed with repeated-measures analysis of variance (ANOVA).
* p<0.01 and **p<0.05; post hoc analysis with Turkey's test.

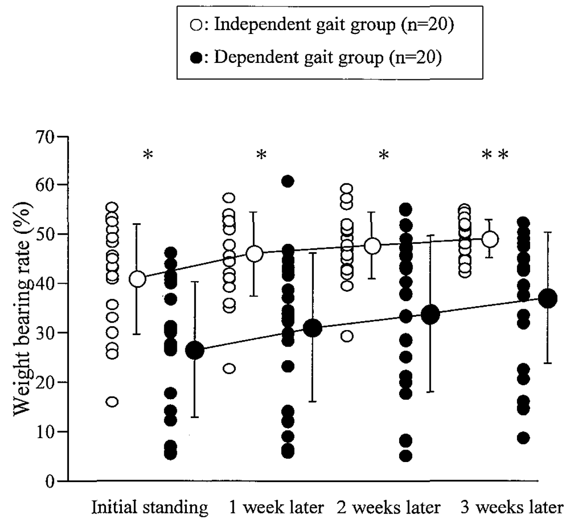

Figure 2. Weight bearing rates of the affected leg over 3 weeks after initial standing
*p<0.01 and **p<0.05; repeated-measures ANOVA with post hoc Turkey's test.
Lines and error bars indicate mean ± SD (standard deviation).

asked to bear their weight on both legs as equally as possible. To minimize an effect of minor standing support, we used average data of 15, 30, and 45 seconds of each weight bearing measurement. The average weight bearing rates of affected leg were 26% to 49% in this study population, which were well corresponded with previous studies of weight bearing rate of 28% to 47% [3, 6-15]. This suggests less possibility of an unintentional bias of weight bearing measurement in this study.

In conclusion, weight bearing measurement is a good objective indicator of early recovery of gait independency after acute stroke. It is useful to monitor the functional recovery process in clinical rehabilitation practice shortly after stroke, because the measurement is relatively simple, taking only one minute.

ACKNOWLEDGMENT

We would thank H. Gohda, RPT, at the Rehabilitation Service of the Hakka Hospital, Y. Kita, MD, and all staffs at the Departments of Rehabilitation Medicine, Neurology, and Neurosurgery, Hyogo Brain and Heart Center, for their help in this study.

REFERENCES

1. Ministry of Health and Welfare in Japan, White paper on Health and Welfare.1998, pp. 246-262 (In Japanese).
2. Yoneda Y, Uehara T, Yamasaki H, et al. Hospital-based study of the care and cost of acute ischemic stroke in Japan. Stroke 34: 718-724, 2003.
3. Eng JJ, Chu KS. Reliability and comparison of weight-bearing ability during standing tasks for individuals with chronic stroke. Arch Phys Med Rehabil 83: 1138-1144, 2002.
4. Goldie PA, Bach TM, Evans OM. Force platform measures for evaluating postural control: reliability and validity. Arch Phys Med Rehabil 70: 510-517, 1989.
5. Nichols DS. Balance retraining after stroke using force platform biofeedback. Phys Ther 77: 553-558, 1997.
6. Sackley CM. The relationships between weight-bearing asymmetry after stroke, motor function and activities of daily living. Physiother Theory Pract 6: 179-185, 1990.
7. Dickstein R, Nissan M, Pillar T, et al. Foot-ground pressure pattern of standing hemiplegic patients: major characteristics and patterns of improvement. Phys Ther 64: 19-23, 1984.
8. Dettmann MA, Linder MT, Sepic SB. Relationships mong walking performance, postural stability, and functional assessment of the hemiplegic patient. Am J Phys Med 66: 77-90, 1987.
9. Mizrahi J, Solzi P, Ring H, et al. Postural stability in stroke patients: vectorial expression of

asymmetry, away activity and relative sequence of reactive force. Med Eng Comput 27: 181-190, 1989.
10. Gruendel TM. Relationship between weight-bearing characteristics in standing and ambulatory independence in hemiplegic. Physiother Can 44: 16-17, 1992.
11. Bohannon RW, Larkin PA. Lower extremity weight bearing under various standing conditions in independently ambulatory patients with hemiparesis. Phys Ther 65: 1323-1325, 1985.
12. Caldwell C, Macdonald D, Macneil K, et al. Symmetry of weight distribution in normals and stroke patients using digital weight scales. Physiotherapy Practice 2: 109-116, 1986.
13. Shumway-Cook A, Anson D, Haller S. Postural sway biofeedback: its effect on reestablishing stance stability in hemiplegic patients. Arch Phys Med Rehabil 69: 395-400, 1988.
14. Winstein CJ, Gardner ER, McNeal DR, et al. Standing balance training: effect on balance and locomotion in hemiparetic adults. Arch Phys Med Rehabil 70: 755-762, 1989.
15. Laufer Y, Dickstein R, Resnik S, et al. Weight-bearing shifts of hemiparetic and healthy adults upon stepping on stairs of various heights. Clin Rehabil 14: 125-129, 2000.
16. de Haart M, Geurts AC, Huidekoper SC, et al. Recovery of standing balance in postacute stroke patients: a rehabilitation cohort study. Arch Phys Med Rehabil 85: 886-895, 2004.
17. Brunnstrom S. Movement therapy in hemiplimbia. New York: Harper & Row, 1970.
18. Mahoney FI, Barthel DW. Functional evaluation: the Barthel Index. Maryland St Med J 14: 61-65, 1965.
19. Fiedler RC, Granger CV. The functional independence measure: a measurement of disability and medical rehabilitation. (In) Functional evaluation of stroke patients. Chino N, Melvin JL, (Ed.) Springer-Verlag Tokyo, pp. 75-92, 1996.
20. Hamrin E, Eklund G, Hillgrin A, et al. Muscle strength and balance in post-stroke patients. Upsala J Med Scil 87: 11-26, 1982.
21. Bohannon RW. Correlation of lower limb strengths and other variables with standing performance in stroke patients. Physiother Can 41: 198-202, 1989.