

■ ORIGINAL ARTICLES

The value of weight-bearing rate on the paretic lower limb for an independent walking without a cane in patients with stroke

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ABSTRACT:

Purpose: The purpose of this study was to determine the cut-off value of the weight-bearing rate (WBR) on the paretic lower limb that is needed for independent walking without a cane.

Methods: The participants were 128 stroke patients. Age, sex, muscle strength of both the paretic and non-paretic lower limbs, Brunnstrom recovery stage of the lower limbs, deep sensation, and the WBR on both the paretic and non-paretic lower limbs were used as variables. The patients who could independently walk in the hospital without a cane were categorized as independent group, and those who walked with a cane, or observation or assistance by a staff member were dependent group.

Results: The WBR on the paretic lower limb was most strongly related to independent walking without a cane, and a WBR value of 80.5% on the paretic lower limb gave a clear cut-off value ($p < 0.05$).

Conclusions: Although multiple factors affect independent walking without a cane in stroke patients, the WBR on the paretic lower limb is the most useful factor for predicting an independent walking without a cane.

Key words: balance, cut-off, walking performance

INTRODUCTION

People with hemiplegic stroke often require assistance in walking due to dysfunction of motor control, decrease of the ability for balance, sensory disturbance, and muscle weakness. To provide more favorable conditions for walking, the choice of a walking aid depends on each individual's needs and deficits¹⁾. Walking aids, such as T-cane or quad cane, are often prescribed for stroke patients whose walking is unstable²⁾.

Ashton-Miller et al.³⁾ studied the use of a cane by peripheral neuropathy patients and concluded that their risk of losing balance on uneven surfaces was significantly reduced by the use of cane. Kuan⁴⁾ stated that the use of walking aids increases stability, reduces the chance of falling and improves independent walking. On the other hand, Sorensen et al.⁵⁾ observed that, at a 3- to 5-year follow-up of post-stroke patients discharged from hospitals with an assistive device. Almost all of the survivors were still dependent on assistive devices and/ or environmental modifications, most frequently wheelchairs and aids for walking and bathing. After returning home, the patients may wish to carry an object while walking, such as a glass, plate, umbrella, or load. When patients with hemiplegia cannot use the paretic upper limb because of motor paralysis, they use the non-paretic upper limb. However, patients cannot carry anything with the non-paretic upper limb if they use a cane with that limb. Therefore, for patients with hemiplegia, walking without a cane enhance a walking ability that is necessary for improving the quality of life and expanding the life range.

Ability to bear weight on the paretic lower limb was generally decreased after a stroke. Numerous studies of standing balance in the stroke patients have consistently demonstrated that increase in the proportion of body weight was observed on the non-paretic lower limb⁶⁻¹²⁾. Ability to bear weight on the paretic lower limb has been shown to relate to performance of

functional tasks such as reaching in sitting^{13,14)}, rising from a chair^{15,16)}, standing^{17,18)}, walking¹⁹⁻²¹⁾, and climbing curbs and stairs^{16,22)}.

Our previous study indicated that a certain level of weight-bearing rate (WBR) for the paretic lower limb must be achieved for indoor walking with a cane after a stroke²³⁾. Thus, we inferred that an another level of WBR for the paretic lower limb is necessary to walk without a cane. Determining the level of WBR on the paretic lower limb required for independent walking without a cane would be useful for assessing the cause of disorders and for selecting therapeutic exercises. Furthermore, information regarding WBR levels required for independent walking without a cane would help motivate such patients to participate in rehabilitation.

Our aim was to investigate the association between walking without a cane and physical function in patients with stroke. Secondly, the purpose of this study was to determine the cut-off value of the WBR on the paretic lower limb that is needed for independent walking without a cane.

SUBJECTS AND METHOD

Participants

One hundred and twenty-eight, who were stroke patients following their first known cerebrovascular accident, participated in this study after their provision of informed consent. All stroke patients have been admitted to rehabilitation hospital. Eighty of the patients were hemiparetic on the right side, and 48 were on the left side. Of the patients, 73 were men and 55 were women. The patients' mean time since onset of hemiplegia was 97.5 ± 56.8 days. Their mean age was 67.0 ± 11.1 years old. Of the patients, one used knee ankle foot orthosis (KAFO), eight used ankle foot orthosis (AFO) and 119 used not orthosis.

The exclusion criteria are a person who accompanied with higher cortical function disorder and who cannot maintain standing

position without arms support.

The study was approved by the ethics committee of Kochi Prefectural University.

Procedure

Walking performance, age, sex, muscle strength of both the paretic and non-paretic lower limbs, Brunnstrom recovery stage of the lower limbs, deep sensation, and the WBR on both the paretic and non-paretic lower limbs were studied.

In the walking performance, the patients who could independently walk in the hospital without a T-cane or quad cane were categorized as the independent group (IG). And the patients who walked with the aid of a cane, or required observation or any assistance by a staff member were categorized as the dependent group (DG). To measure the muscle strength of the lower limb, quadriceps muscle strength was measured using a hand-held dynamometer (ANIMA, μ -Tas MT-01). With the patients sitting upright on a mat platform, with both upper extremities crossing in front of the trunk, without back support, and keeping the knees flexed 90 degrees. The dynamometer was attached to the front of the distal crus. The patients were then asked to make a maximum isometric contraction of the quadriceps for 5 s, in twice, with a time interval of more than 30 s. The stronger value (kgf) of the two was divided by the body weight, and this value (kgf/kg) was defined as the muscle strength of the lower limb.

A level of motor paralysis was evaluated by the measurement of Brunnstrom's six recovery stages²⁴. The lowest stage, flaccid stage and no voluntary movement, defined as stage 1, and the highest stage, isolated joint movement and not normal movement, defined as stage 6.

A level of joint sensation was evaluated by the measurement of deep sensation. First, the patient's hip, knee, and ankle were moved to any angle by the examiner, and then the patient was asked to imitate the movements on

the non-paralyzed side. Measurement of each joint sensation was performed five times; a difference between paralytic and non-paralytic side of up to 10 degrees in the joints was considered normal, while a difference of ≥ 11 degrees at least once was considered abnormal.

The WBR was taken using two commercially available weighting scales (TANITA bathroom scales RAINBOW THA-528). Each scale has a precision of 1.0 kg, and the measurement range is 0-120 kg. The scales were placed side by side. The angle between the right and left feet was approximately 15 degrees, and the distance between the two calcaneal regions was approximately 10 cm. The patients maintained standing position without arms support in an eye opening. And they were asked to stand evenly with one foot on each scale, and they were then asked to shift as much of their weight as possible to the non-paretic side and then to the paretic side, and to then keep that position stably for a minimum of 5 s. Each side of WBRs was measured during stood still for 5 s. The WBR was defined as the percentage of the weight shown on each scale for the total body weight. Representative values were selected as the higher of two measurements.

Data analysis

The differences between IG and DG were compared using the independent *t*-test, the χ^2 test, and the Mann-Whitney U test. Logistic regression analysis was used with walking performance as the dependent variable, and all other assessments were used as independent variables. The usefulness of the WBR on the paretic lower limb for predicting independent walking without a cane was studied using a receiver operating characteristic (ROC) curve, and the cut-off value (highest sensitivity and specificity) necessary for independent walking without a cane was determined by the ROC curve. Predictability was evaluated using the sensitivity, false-positive rate (1-specificity), the positive predictive value (proportion of

patients with positive results who were correctly diagnosed by cut-off value), and negative predictive value (proportion of patients with negative results who were correctly diagnosed by cut-off value).

IBM SPSS Statistics 22.0 was used for data analysis. The results were defined as being statistically significant when the possibility of error (p) was less than 5%.

Table 1 Comparison of variables between IG and DG (n= 128)

Variable	IG (n=53)	DG (n=75)	test	p value
Age (y)	65.2 ±12.2	68.3 ±10.2	t	.112
Sex(male/ Female) (n)	35/18	38/37	χ ²	.047
Muscle strength of the paretic lower limb (kgf/kg)	0.42 ±0.16	0.21 ±0.13	t	.000
Muscle strength of the non-paretic lower limb (kgf/kg)	0.53±0.18	0.45 ±0.16	t	.007
Brunnstrom recovery stage of lower limbs (n)	III: 1, IV:4, V:9, VI:39	II :2, III:23, IV:19, V:21, VI:10	U	.000
Deep sensation (normal/ abnormal) (n)	41/12	31/44	χ ²	.000
WBR on the paretic lower limb (%)	88.5±7.4	54.4±22.6	t	.000
WBR on the non-paretic lower limb (%)	91.2±5.9	86.2 ±10.6	t	.001

For t test, mean ±SD is reported; for Mann-Whitney U test and χ² test, proportion are reported.

Table2 Predictors of walking without a cane performance (n=128)

Variable	Odds ration (95%CI)	p value
Sex(male/ Female) (n)	0.422 (0.1-1.781)	.240
Muscle strength of the paretic lower limb (kgf/kg)	412.252 (0.164-1033568.3)	.132
Muscle strength of the non-paretic limb (kgf/kg)	0.232 (0.001-57.481)	.603
Brunnstrom recovery stage of lower limbs (n)	1.895 (0.739-4.860)	.184
Deep sensation (normal/ abnormal) (n)	0.865 (0.202-3.704)	.845
WBR on the paretic lower limb (%)	1.199 (1.078-1.333)	.001
WBR on the non-paretic lower limb (%)	1.030 (0.898-1.181)	.676

CI: confidence interval.

RESULTS

Of the 128 patients, 53 were in IG and 75 are in DG. The results of the univariate analysis were shown in Table 1. Age was not significantly different between the two groups.

But sex, muscle strength of both the paretic and non-paretic lower limbs, Brunnstrom recovery stage of the lower limbs, deep sensation, and the WBR on both the paretic and non-paretic lower limbs were significantly different between these two groups (p<0.05).

Logistic regression analysis of the seven variables showed that only the WBR on the paretic lower limb was a significantly associated with walking without a cane ($p < 0.05$) (Table 2).

The results of the ROC curve analysis indicated that WBR on the paretic lower limb were most strongly related to independent walking without a cane. The area under the curve was 0.951, with SE 0.016 and 95% Confidence Interval was 0.919–0.983. A WBR of 80.5% on the paretic lower limb gave a clear cut-off value, with a sensitivity of 86.8%, a false-positive rate (1-specificity) of 13.3%, a positive predictive value of 82.1%, and a negative predictive value of 90.3% (Figure).

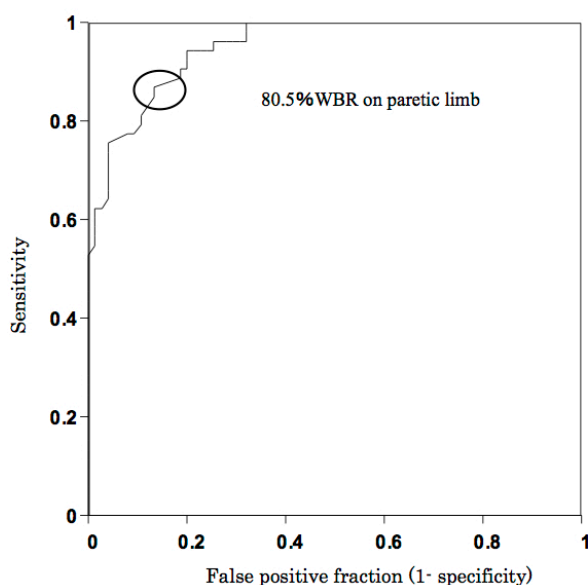


Figure. ROC Curve for prediction of independence WWC (n=128)
The areas under the curve is 0.951, with SE 0.016 and 95%
Confidence Interval 0.919–0.983.

DISCUSSION

The purpose of this study is to determine the cut-off value of the WBR on the paretic lower limb that is needed for independent walking without a cane. The present study shows that the WBR on the paretic lower limb is most strongly related to independent walking without a cane.

WBR is used for an evaluation of the balance ability because WBR are significantly

correlated with one leg standing time²³. And the method for measuring the WBR that is used in the present study has been reported to have a high reproducibility²⁵.

Weight-bearing through the paretic lower limbs during standing has been found to correlate significantly with Barthel index scores of function⁸. Richard and Bohannon showed that walking and stair performance in hemiparetic persons were significantly correlated with maximum weight bearing through the paretic lower limb^{21, 26}. We also reported that WBR on the paretic lower limb had an influence on the indoor walking with a cane²³.

Our current study show that on univariate analysis, factor except the age are significantly different between IG and DG (Table 1). The logistic regression analysis show that only the WBR on the paretic lower limb is a critical factor influencing the ability for independent walking without a cane (Table 2). Therefore, although multiple factors influence independent walking without a cane in stroke patients, the WBR on the paretic lower limb is the most useful indicator for predicting independent walking without a cane. During the stance portion of the walking cycle, the hemiparetic patient typically demonstrates relatively limit weight transfer to the paretic lower limb; and single-stance duration is relatively shorter for the paretic lower limb than for the non-paretic lower limb^{27, 28}. Several studies of standing balance in hemiparetic adults have consistently demonstrated a greater proportion of body weight distributed on the non-paretic lower limb than on the paretic lower limb^{7, 8}. Stroke patients have the greatest difficulties in transferring weight onto their paretic lower limb. Patients who wish to walk without a cane need to maintain balance through stable support provided by both lower limbs. If the WBR for the paretic lower limb is high, the patient can walk stably while using it.

Therefore, in this study, it is considered that the WBR for the paralyzed side is most associated with walking without independence from cane use in stroke patients.

The probability for a given patient being able to walk without a cane is positive predictive value of 82.1% and negative predictive value of 90.3% if the subjects spontaneously load the paretic lower limb over 80.5% WBR on the paretic lower limb. Insufficient loading may be compensated by additional support such as cane. Our study suggests that any asymmetry corresponding to 80.5% WBR on the paretic lower limb would be a fair target for rehabilitation.

There are three limitations to this study. First, we do not include a higher cortical function disorder, therefore the results of our study are applicable only to patients without a higher cortical function disorder. Second, we do not examine WBR at a dynamic walk, because WBR which we evaluate in current study is static balance. Third, this results may differ, because muscle strength of the lower limb do not measure lever arm length. Further research is needed to determine.

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