■ ORIGINAL ARTICLE

Relationship between weight bearing rate on the paretic limb and one leg standing time of paretic limb in patients after stroke

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ABSTRACT: In this study, the usefulness of the weight bearing rate (WBR) for judging gait independence and the relationship between the WBR on the paretic limb and one-leg standing time (OLST) on the paretic limb were examined. The participants were 124 stroke patients. The Brunnstrom stage of the lower limbs, OLST of both the paretic and non-paretic limbs, and the WBR on both the paretic and non-paretic limbs were used as variables. The patients were categorized based on their gait ability into an independent group (IG) and a dependent group (DG). Results showed all variables were significantly different between the IG and DG groups ($p < 0.05$). An especially significant correlation was found between the WBR on the paretic limb and independent gait ($p < 0.05$). When the OLST on the paretic limb was <4 s, the WBR on the paretic limb was 4-90%; when the OLST on the paretic limb was >5 s, the WBR on the paretic limb was > 79%. The logistic regression analysis showed that only the WBR on the paretic limb was a significant predictor of independent gait. Therefore the WBR on the paretic limb was most useful for predicting independent gait.

Key words: stroke, weight bearing, gait

INTRODUCTION

In cerebrovascular hemiplegic patients (stroke patients), static balance and dynamic balance have been investigated. To investigate balance, many methods are used, such as foot ground pressure [1], one leg standing time (OLST) [2], weight bearing rate (WBR) [3,4], timed up and go test [5,6], Berg balance scale [7], and the Functional reach test [8]. In particular, the OLST is used in many hospitals and institutions because it is simple to do OLST alone or as an item in the Fugl-Mayer and Berg balance scale [8, 9]. The ability to maintain a one-leg stance has been shown to correlate strongly with falls [10, 11], and it is an important predictor of injurious falls in the elderly [10]. Bohannon described the mean OLST by generation in healthy subjects [2]. However, in stroke patients, motor paralysis, sensory disturbance, and muscle weakness interfere with balancing ability, and one-leg standing on the paretic limb may be difficult.

Evaluation of the WBR on the paretic limb is similar to OLST. It is measured by moving the body weight from standing to the paretic side, and it can measure balance of patients whose OLST on the paretic limb is difficult to evaluate. Richard demonstrated that both maximum weight bearing on the paretic limb and paretic knee extension strength are valid predictors of gait speed in stroke patients [12]. We found that a certain minimum WBR on the paretic limb was necessary for independent going up and down stairs in stroke patients [3]. Thus, weight bearing ability correlates with functional performance in individuals with stroke. If WBR on the paretic limb is a possible objective and detailed evaluation, it is useful for assessing the outcome of rehabilitation and relief of problems in stroke patients.

The aim of this study was to determine the usefulness of the WBR for judging gait independence, and the relationship between the WBR on the paretic limb and the OLST on the paretic limb.

MATERIALS AND METHODS

SUBJECTS

The subjects were 124 stroke patients in the Koseinenkin Kochi Rehabilitation Hospital. Summaries of the patients characteristics are presented in table 1. All patients provided informed consent. All patients could maintain a standing position without any supporting devices, and none had a high cortical function disorder.

Table1 Characteristics of 124 stroke patients

Characteristic	N or X
Age(y)	67
Sex	
Male	74
Female	50
time from the onset(d)	97
Paralytic side	
Right	76
Left	48
Brunnstrom stage of lower limb	
Ⅱ	3
Ⅲ	23
Ⅳ	20
Ⅴ	29
Ⅵ	49

METHODS

The Brunnstrom stage of the lower limbs [13], OLST of both the paretic and non-paretic limbs, the WBR on both the paretic and non-paretic limbs, and gait performance were measured.

The WBR was taken using two commercially available 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 15 degrees, and the distance between the two calcaneal regions was 10 cm. The patients were asked to stand evenly with one foot on each scale without the support of the upper limbs. Then, they were asked to shift as much of their weight as possible to the non-paretic side or the paretic side, and hold the position stably for a minimum of 5 s. The scale measured the value (in 1-kg units) during which the patient stood still for 5 s. The WBR was defined as the percentage of the weight shown on each scale compared to the whole body weight. The method for measuring the WBR that was used in the present study has been reported to have a high reproducibility [4].

For the OLST, the patients were asked to stand on one leg at a time, with their eyes open and with their non-paretic hands on their hips. The test was over when the patients were not able to maintain their balance and the suspended leg touched the floor. The performance time was measured using a stop watch. The OLST was taken as the maximum of three separate measurements. The maximum achievable OLST was 30 s.

For measurement of gait performance, the patients who could walk in the hospital independently and safely were categorized as the independent group (IG), and those who needed observation or any assistance by a staff member were the dependent group (DG).

The differences between IG and DG were compared using the Mann-Whitney U test and the *t*-test. Logistic regression analysis was used to identify the best independent predictors of independent gait. The usefulness of the WBR on the paretic limb for predicting independent gait was studied using a receiver operating characteristic (ROC) curve, and the cut-off value necessary for independent gait was determined.

Pearson product moment correlation was used to determine correlations between the WBR on the paretic limb and the OLST on the paretic limb. Statistical analysis was performed using SPSS version 15.0 J Windows. The significance of relationships was evaluated at the $p < 0.05$ level.

RESULTS

IG contained 69 patients, and DG contained 55 patients. The results of the univariate analysis are shown in Table 2. The Brunnstrom stage of the lower limbs, OLST of both the paretic and non-paretic limbs, and the WBR on both the paretic and non-paretic limbs were significantly different between the two groups ($p < 0.05$).

Logistic regression analysis of the five variables (Brunnstrom stage of the lower limbs, OLST of both the paretic and non-paretic limbs, the WBR on both the paretic and non-paretic limbs) showed that only the WBR on the paretic limb was a significant predictor of independent gait (table 3).

A WBR of 70.2% on the paretic limb gave a clear cut-off value, with a sensitivity of 92.6%, a false-positive rate (1-specificity) of 12.7%, a predictive accuracy of 91.1%, and a positive predictive value of 91.5% (Fig. 1).

There was a significant positive correlation between the WBR on the paretic limb and OLST on the paretic limb ($r=0.47$; $p < 0.05$). The relationship between the WBR on the paretic limb and OLST on the paretic limb is shown in Fig. 2. The OLST on the paretic limb and the WBR on the paretic limb were: 0 s, 4-87%; 1 s, 57-87%; 2 s, 64-92%; 3 s, 78-89%; 4 s, 69-90%, and > 5 s, 79-99%, respectively. Of the 57 patients with an OLST of 0 s, 11 had independent gait; of the 11 patients with an OLST of 1 s, 6 had independent gait; of the 7 patients with an OLST of 2 s, 5 had independent gait; of the 6 patients with an OLST of 3 s, 5 had independent gait; all patients with an OLST of 4 s had an independent gait; and all 39 patients with an OLST of > 5 s had independent gait.

Table2　Comparison of valuables between independent group and dependent group　(n=124)

Variable	Independent group (n=69)	Dependent group (n=55)	test	p value
Brunnstrom stage of lower limbs (n)	Ⅲ: 5, Ⅳ:5, Ⅴ:17, Ⅵ:42	Ⅱ:3, Ⅲ:18, Ⅳ:15, Ⅴ:12, Ⅵ:7	U	<.001
One leg standing time of the paretic limb (s)	18.2 ±25.7	0.2 ±0.6	t	<.001
One leg standing time of the non-paretic limb (s)	27.6 ±27.0	4.6±7.9	t	<.001
Weight bearing rate on the paretic limb (%)	85.9 ±8.6	47.2±20.7	t	<.001
Weight bearing rate on the non-paretic limb (%)	90.7±5.9	85.1 ±11.7	t	.002

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

Table3　Predictors of gait ability (n=124)

Variable	Odds Ratio (95%CI)	p value
Brunnstrom stage of lower limbs (n)	0.623 (0.212-1.835)	.391
One leg standing time of the paretic limb (s)	1.707 (0.872-3.339)	.118
One leg standing time of the non-paretic limb (s)	1.019 (0.96-1.083)	.532
Weight bearing rate on the paretic limb (%)	1.189 (1.067-1.326)	.002
Weight bearing rate on the non-paretic limb (%)	0.955(0.851-1.072)	.435

CI: confidence interval.

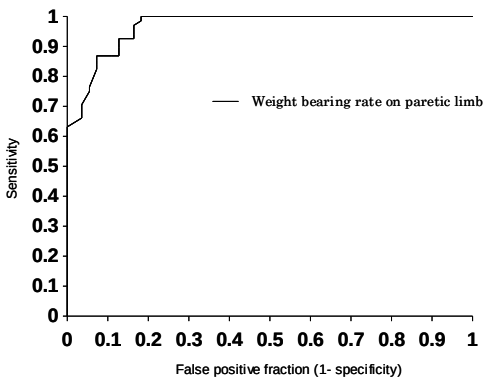

Fig. 1　Receiver operating characteristic curve for prediction of independence indoors gait (n=124). The areas under the curve is 0.968, with SE 0.013 and 95% Confidence Interval 0.943–0.994.

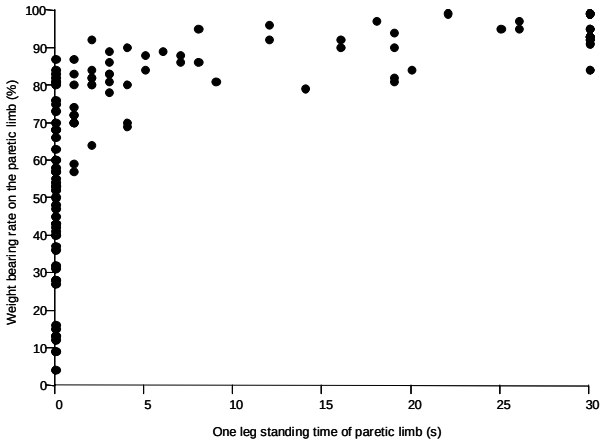

Fig.2 Scatterplot demonstrates the relationship between weight bearing rate on the paretic limb and one leg standing time of paretic limb among 124 stroke patients.

DISCUSSION

The purpose of this study was to determine the usefulness of the WBR for judging gait independence, and the relationship between the WBR on the paretic limb and the OLST on the paretic limb. The WBR on the paretic limb was the most useful predictor of independent gait, and there was a significant correlation between the WBR on the paretic limb and OLST on the paretic limb. OLST on the paretic limb of < 4 s was associated with a wide range of WBR on the paretic limb.

The present study showed that the Brunnstrom stage of the lower limbs, OLST on both the paretic and non-paretic limbs, and the WBR on both the paretic and non-paretic limbs were significantly different between IG and DG. Analyzing the Logistic regression, the WBR on the paretic limb was the most useful predictor of independent gait. Although multiple factors influenced the gait of stroke patients, the WBR on the paretic limb was the most important.

Richard and Bohannon showed that gait and stair performance in hemiparetic persons were significantly correlated with maximum weight bearing on the paretic limb [12, 14]. We previously demonstrated that the WBR on the paretic limb was significantly associated with muscle strength of the paretic limb, Brunnstrom stage of the lower limbs, and deep sensation, and a WBR on the paretic limb of 71% gave a clear cut-off value for an independent indoor gait with a sensitivity of 93.3%, a false-positive rate (1-specificity) of 14.7%, a predictive accuracy of 89.9%, and a positive predictive value of 89.4% in stroke patients [4]. This study showed that the cut-off value for independent gait was a WBR on the paretic limb of 70.2%, with a high sensitivity, predictive accuracy, and positive predictive value. These results support preliminary research, and gait independence requires a WBR on the paretic limb of > 70%.

The present study showed a positive correlation between the paralysis-side WBR and OLST. However, for an OLST on the paretic limb under 4 s, the WBR on the paretic limb was distributed over a large range. The present study showed that 57 (46.0%) of 124 patients were unable to maintain one-leg standing on the paretic limb. These patients, who had an OLST on the paretic limb of 0 s, had a wide variation (4-87%) in the WBR on the paretic limb, and 10 (17.5%) of 57 patients had independent gait. The support power of paralysis-side lower limbs decreases with muscle weakness, voluntary movement decrease, and sensory disturbance. Several studies of standing balance in hemiparetic adults have consistently demonstrated a greater proportion of body weight distributed on the non-paretic limb than on the paretic limb [1, 15, 16]; stroke patients have the greatest difficulties in transferring weight onto their paretic limb. While standing on only the paretic limb, balance is difficult to maintain. In patients having OLST on the paretic limb of 0 s, the WBR on the paretic limb can help provide a more detailed evaluation of balance, and in such cases, the WBR on the paretic limb provides a better evaluation of the degree of difficulty than OLST of the paretic limb.

Fugl-Meyer reported that a subject is supposed to stand unsupported for at least 10 s when evaluating OLST [9]. Using Tinetti's Balance Subscale, a subject has an alleged normal balance if they are able to stand on one leg without support for 5 s [17]. In this study, stroke patients having OLST > 5 s on the paretic limb had a WBR > 79% on the paretic limb. Patients having an OLST < 4 s on the paretic limb had a WBR on the paretic limb that ranged from 4-92%. Patients with poor balance ability are included among the patients with strokes who have OLST on the paretic limb of < 4 s. Therefore, stroke patients who have OLST on the paretic limb < 4 s should also have their WBR evaluated.

WBR and OLST are convenient to use in hospitals and institutions. In stroke patients

with good balance, OLST provides a sufficient evaluation. However, in patients with poor balance, it is necessary to measure the WBR, since detailed evaluation may be difficult using only the OLST.

A limitation of this study was that only static balance was measured. The measurement of dynamic balance, such as the timed up and go test and the Berg balance scale, can influence activities of daily living. Thus, research on dynamic balance is needed.

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