Different cutoff values for 10-m walking speed simply classification of walking independence in stroke patients with or without cognitive impairment

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Abstract. [Purpose] The aim of this study was to determine the threshold for classifying walking independence in stroke patients with and without cognitive disorders. [Subjects] The subjects were 130 patients with initial stroke hemiplegia. [Methods] The following factors were analyzed for associations with walking independence: Brunnstrom stage, one-leg standing time on the paralytic side, one-leg standing time on the non-paralytic side, and 10-m walking speed. We classified the patients with Mini-Mental State Examination (MMSE) scores ≥24 points into the high-score group and those with MMSE scores of ≤23 points into the low-score group and examined the main factors and cutoff values associated with walking independence in each group. [Results] The high-score group included 69 subjects (53.1%), and the low-score group included 61 subjects (46.9%). The primary factor associated with high MMSE scores among the stroke patients was the 10-m walking time. Using a cutoff level for the 10-m walking speed of 41.4 m/min resulted in a positive likelihood ratio of 6.3. The primary factor associated with low MMSE scores among the stroke patients was the 10-m walking time. Using a cutoff level for the 10-m walking speed of 48.0 m/min resulted in a positive likelihood ratio of 7.6. [Conclusion] The cutoff value for the 10-m walking speed can be used to evaluate walking independence in patients with stroke among patients with high or low MMSE scores.
Key words: Walking, Cognition disorders, Stroke

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INTRODUCTION

Assessing the degree of walking independence among inpatients is one of the important roles of physical therapists. Overestimation of a patient's ability to walk can result in falls, whereas underestimation can lead to disuse syndrome due to a decrease in physical activity. Preliminary research investigating cutoff values for parameters of walking independence in patients with stroke has reported the efficacy of physical performance examinations such as assessments of walking speed[1]. However, preliminary studies often exclude stroke patients with cognitive disorders in order to increase the rate of identifying patients with walking independence and improve the reliability of examinations. Stroke patients with cognitive disorders are often examined in the clinical setting[2, 3], where the cutoff value for excluding stroke patients with cognitive disorders in preliminary research cannot be used to evaluate those with cognitive disorders. As a result, walking independence in stroke patients with cognitive disorders is presently being assessed on the basis of subjective assessment by a physical therapist, and no clear protocol exists regarding this issue. Therefore, determination of the cutoff values for parameters of walking independence in patients with stroke and cognitive disorders is necessary. But there have been few studies so far that have evaluated the reference values associated with walking independence in stroke patients with a cognitive impairment[4].

The purpose of this study was to determine the threshold for classifying walking independence in stroke patients with and without cognitive disorders.

SUBJECTS AND METHODS

The subjects included 130 patients with initial stroke hemiplegia admitted to the rehabilitation unit at Koseinenkin Kochi Rehabilitation Hospital in Japan from April 2007 through December 2012. Patients were eligible for inclusion if they met the following criteria: (1) age ≥40 years; (2) more than one month had passed since stroke onset; (3) ability to complete the Mini-Mental State Examination (MMSE) (total score: >1)[5]; (4) first stroke, i.e., no previous history of stroke; (5) ability to walk a minimum of 10 m using mobility

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Table 1. Characteristics of the high-score group and low-score group

Variable	Walking status	
	Dependent	Independent
High-score group		
No. of patients	29	40
Age (years)†	72.4 (11.8)	68.9 (11.3)
Female (%)†	62.1	40.0
Left-sided hemiplegia (%)	58.6	52.5
Time after stroke onset to measurement (m)†	3.5 (2.4)	2.4 (2.2)
Brunnstrom stage (1–6)‡	0.0.11.3.10.5	0.0.0.2.5.33*
One-leg standing time on the paralytic side(s)†	0.4 (1.3)	10.4 (15.4)*
One-leg standing time on the non-paralytic side(s)†	2.3 (5.3)	13.6 (18.2)*
10-m walking speed (m/min)†	23.9 (21.5)	82.2 (47.5)*
Low-score group		
No. of patients	40	21
Age (years)†	79.4 (6.9)	76.4 (7.9)
Female (%)†	62.5	33.3*
Left-sided hemiplegia (%)	50.0	19.0*
Time after stroke onset to measurement (m)†	3.1 (0.9)	2.3 (0.7)*
Brunnstrom stage (1–6)‡	0.0.3.6.16.15	0.0.0.1.1.19*
One-leg standing time on the paralytic side(s)†	0.38 (0.74)	3.8 (3.5)*
One-leg standing time on the non-paralytic side(s)†	0.9 (1.7)	4.8 (3.3)*
10-m walking speed (m/min)†	24.5 (17.6)	71.7 (21.0)*

*$p<0.05$. †Student's t-test. ‡Mann-Whitney test

aids such as a cane or a brace; and (6) a history of independent activities of daily living before the onset of stroke.

We investigated basic information in addition to walking status, physical function, and performance of the patients during physical therapy based on their medical records. The survey items included gender, age, side of paralysis, functional independence measure (FIM) for walking[6], MMSE score, lower limb Brunnstrom stage[7], one-leg standing time on the paralytic side, one-leg standing time on the non-paralytic side, and 10-m walking speed.

For measuring the one-leg standing time, we measured the duration for which the patients were able to maintain one leg in the air without touching the floor[8, 9]. We excluded the measurements of one-leg standing time in the following cases: swaying while balancing, using the arms for balancing, hopping to maintain balance, and putting the foot down on the floor. The maximum measurement time was 60 s. The time before falling over was measured, and the maximum time of two repetitions was determined.

The 10-m walking speed was used to quantify the ambulatory status in terms of a fast gait speed[10]. The 10-m distance was measured indoors on a 1-m runaway. The participants were instructed to walk at their fastest and safest speed. The time from the starting line to a line marking 10 m was measured using a stopwatch. The participants performed two trials at each speed, and the calculated walking speed (m/min) was recorded.

We conducted the statistical analysis according to the presence or absence of cognitive disorders. We classified the patients with MMSE scores of ≥24 points into the high-score

group and those with MMSE scores of ≤23 points into the low-score group[11]. The MMSE is a brief 30-point questionnaire test used to evaluate cognitive function[5]. The MMSE measures various domains of cognitive functioning including memory, orientation to place and time, naming, reading, visuospatial orientation/construction ability, writing, and the ability to follow a 3-stage command. It is difficult to diagnose inattention and accomplishment dysfunction in patients with stroke using the MMSE. Therefore, patients with a deteriorated cognitive function may have been included in the high-score group.

The statistical analysis was conducted to investigate the main factors associated with walking independence using a logistic regression analysis. The cutoff levels for the main factors used to distinguish walking independence were determined according to the compatibility of the regression models using the area under the curve (AUC) of the receiver operating characteristic (ROC) curve and the Youden index[12]. We calculated test diagnostics (sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, and negative likelihood ratio) for a series of cutoff points. The level of significance was set at <5%. Subjects were included after obtaining informed consent, and the study protocol was approved by the Ethics Committee of Seirei Christopher University.

RESULTS

The high-score group included 69 subjects (53.1%), and the low-score group included 61 subjects (46.9%) (Table 1).

Table 2. Results of the logistic regression analysis

Variable	B	Odds ratio	95% confidence interval
High-score group			
10-m walking speed*	0.073	1.076	1.042–1.111
Constant	−3.044		
Identification rate	87.0		
Low-score group			
10-m walking speed*	0.107	1.113	1.045–1.186
One-leg standing time on the non-paralytic side†	0.495	1.640	0.969–2.777
Constant	−7.146		
Identification rate	88.5		

Dependent variable: walking status (dependent, 0; independent, 1)
Independent variable: 10-m walking speed and one-leg standing time on the non-paralytic side
*Odds ratio for a 1 m/min increase
†Odds ratio for a 1-second increase

In the high-score group, the incidence of walking independence was 40 of 69 (58.0%) patients with maintained cognitive function. According to the logistic regression analysis, the main factor associated with walking independence in the high-score group was the 10-m walking speed (odds ratio, 1.076; 95% confidence interval, 1.042–1.111) (Table 2). As for the compatibility of the regression models of the ROC curve, the AUC was 0.921. Using a cutoff level for the 10-m walking speed of 41.4 m/min resulted in a sensitivity of 87.5%, specificity of 86.2%, positive predictive value of 90.0%, negative predictive value of 83.3%, positive likelihood ratio of 6.3, and negative likelihood ratio of 0.2 (Fig. 1).

The incidence of walking independence in the low-score group was 21 of 61 (34.4%) patients with impaired cognitive function. According to the logistic regression analysis, the main factor associated with walking independence in the low-score group was the 10-m walking speed (odds ratio, 1.113; 95% confidence interval, 1.045–1.186) (Table 2). With regard to the compatibility of the regression models of the ROC curve, the AUC was 0.953. Using a cutoff level for the 10-m walking speed of 48.0 m/min resulted in a sensitivity of 95.2%, specificity of 87.5%, positive predictive value of 89.5%, negative predictive value of 80.6%, positive likelihood ratio of 7.6, and negative likelihood ratio of 0.1 (Fig. 1).

DISCUSSION

The patients in the low-score group based on the examinations for the presence of cognitive disorders accounted for 50% of all subjects. The subjects of this study included patients with initial stroke hemiplegia who had been treated in the rehabilitation unit at Koseinenkin Kochi Rehabilitation Hospital. On the basis of preliminary research, studies have reported that these exclusion criteria are related to cognitive impairment[13]. Furthermore, most stroke patients hospitalized in rehabilitation units have cognitive disorders[14]. It has become clear that patients with a history of several strokes cannot be evaluated using the cutoff values employed in preliminary research that excludes patients with cognitive disorders.
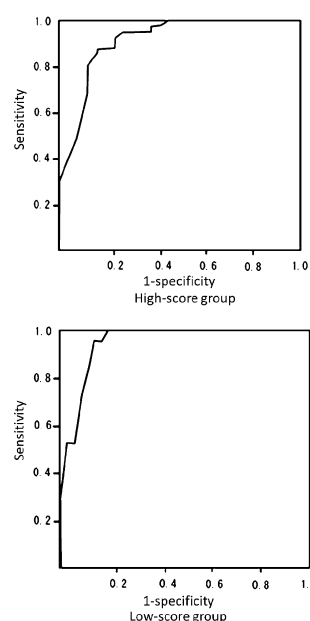

Fig. 1. The AUC was 0.921 in the high-score group. Using a cutoff level for the 10-m walking speed of 41.4 m/min resulted in a sensitivity of 87.5% and a specificity of 86.2%. The AUC was 0.953 in the low-score group. Using a cutoff level for the 10-m walking speed of 48.0 m/min resulted in a sensitivity of 95.2% and a specificity of 87.5%.

The results of this study showed that the primary factor associated with walking independence in the high-score group of stroke patients was the 10-m walking time. Patients with a high 10-m walking speed are likely to exhibit walking independence. Preliminary studies have found that the walking speed can be used to classify patients according to the degree of walking independence in the community[15]. Van de Port et al. investigated the cutoff value of walking speed for community walkers with stroke and reported a positive predictive value of 93% and a negative predictive value of 57% for a cutoff value of 0.66 m/s, with an AUC of 0.85[15].

It is clear from these results that there is a standard value for classifying walking independence with walking speed. This study demonstrated the 10-m walking speed to be an effective parameter for identifying walking independence in the hospital.

In the present study, the main factor associated with walking independence in the low-score group of stroke patients was the 10-m walking time. Patients with a high 10-m walking time are likely to exhibit walking independence. Therefore, the 10-m walking speed is an effective parameter for classifying stroke patients with cognitive disorders according to the degree of walking independence in the hospital. Examinations using complicated instructions decrease the reliability of assessments of physical function in patients with deteriorated cognitive function. It is therefore necessary to use simple examinations in patients with cognitive function disorders. We used the 10-m maximal walking speed to examine the walking independence status in this study. Cognitive impairment in patients with stroke results in significant inattention and accomplishment dysfunction[16]. Patients with cognitive function disorders have difficulty in maintaining attention during long examinations and performing the required movements in assessments with complicated instructions[17]. Measuring the 10-m walking speed is an effective laboratory procedure due to its simplicity and allows for the determination of walking independence in patients evaluated with the MMSE.

REFERENCES

1) Narita J: The relationship of gait speed and indoor walking independency in hemiplegic stroke patients. Rigakuryoho Kagaku, 2008, 23: 419–424. [CrossRef]

2) Pohjasvaara T, Erkinjuntti T, Vataja R, et al.: Dementia three months after stroke. Baseline frequency and effect of different definitions of dementia in the Helsinki Stroke Aging Memory Study (SAM) cohort. Stroke, 1997, 28: 785–792. [Medline] [CrossRef]

3) Sundar U, Adwani S: Post-stroke cognitive impairment at 3 months. Ann Indian Acad Neurol, 2010, 13: 42–46. [Medline] [CrossRef]

4) Cho KH, Lee JY, Lee KJ, et al.: Factors related to gait function in post-stroke patients. J Phys Ther Sci, 2014, 26: 1941–1944. [Medline] [CrossRef]

5) Folstein MF, Folstein SE, McHugh PR: "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res, 1975, 12: 189–198. [Medline] [CrossRef]

6) Ottenbacher KJ, Hsu Y, Granger CV, et al.: The reliability of the functional independence measure: a quantitative review. Arch Phys Med Rehabil, 1996, 77: 1226–1232. [Medline] [CrossRef]

7) Brunnstrom S: Motor testing procedures in hemiplegia: based on sequential recovery stages. Phys Ther, 1966, 46: 357–375. [Medline]

8) Flansbjer UB, Blom J, Brogårdh C: The reproducibility of Berg Balance Scale and the Single-leg Stance in chronic stroke and the relationship between the two tests. PM R, 2012, 4: 165–170. [Medline] [CrossRef]

9) Bohannon RW, Walsh S, Joseph MC: Ordinal and timed balance measurements: reliability and validity in patients with stroke. Clin Rehabil, 1993, 7: 9–13. [CrossRef]

10) Flansbjer UB, Holmbäck AM, Downham D, et al.: Reliability of gait performance tests in men and women with hemiparesis after stroke. J Rehabil Med, 2005, 37: 75–82. [Medline] [CrossRef]

11) Bour A, Rasquin S, Boreas A, et al.: How predictive is the MMSE for cognitive performance after stroke? J Neurol, 2010, 257: 630–637. [Medline] [CrossRef]

12) Perkins NJ, Schisterman EF: The inconsistency of "optimal" cutpoints obtained using two criteria based on the receiver operating characteristic curve. Am J Epidemiol, 2006, 163: 670–675. [Medline] [CrossRef]

13) Paolucci S, Grasso MG, Antonucci G, et al.: Mobility status after inpatient stroke rehabilitation: 1-year follow-up and prognostic factors. Arch Phys Med Rehabil, 2001, 82: 2–8. [Medline] [CrossRef]

14) Leys D, Hénon H, Mackowiak-Cordoliani MA, et al.: Poststroke dementia. Lancet Neurol, 2005, 4: 752–759. [Medline] [CrossRef]

15) van de Port IG, Kwakkel G, Lindeman E: Community ambulation in patients with chronic stroke: how is it related to gait speed? J Rehabil Med, 2008, 40: 23–27. [Medline] [CrossRef]

16) Graham NL, Emery T, Hodges JR: Distinctive cognitive profiles in Alzheimer's disease and subcortical vascular dementia. J Neurol Neurosurg Psychiatry, 2004, 75: 61–71. [Medline]

17) Wade DT, Wood VA, Hewer RL: Recovery of cognitive function soon after stroke: a study of visual neglect, attention span and verbal recall. J Neurol Neurosurg Psychiatry, 1988, 51: 10–13. [Medline] [CrossRef]