J. Phys. Ther. Sci. 35: 257–264, 2023

The Journal of Physical Therapy Science

Original Article

Predictive discriminative accuracy of walking abilities at discharge for community ambulation levels at 6 months post-discharge among inpatients with subacute stroke

Tatsuya Igarashi, RPT, MSc[1, 2)*], Ren Takeda, RPT[1, 2)], Yuta Tani, RPT[1, 2)], Naoya Takahashi, RPT[1)], Takuto Ono, RPT[1)], Yoshiki Ishii, RPT[3)], Shota Hayashi, RPT, MSc[4)], Shigeru Usuda, RPT, PhD[2)]

[1)] *Physical Therapy Division, Department of Rehabilitation, Numata Neurosurgery and Cardiovascular Hospital: 8 Sakaecho, Numata-shi, Gunma 378-0014, Japan*
[2)] *Gunma University Graduate School of Health Sciences, Japan*
[3)] *Numata Clinic, Japan*
[4)] *Department of Physical Therapy, Gunma Paz University, Japan*

Abstract. [Purpose] This study aimed to compare the predictive accuracy of walking ability at discharge among subacute stroke inpatients at 6 months post-discharge in terms of community ambulation level and establish optimal cut-off values. [Participants and Methods] This prospective observational study included 78 patients who completed follow-up assessments. Patients were classified into three groups based on the Modified Functional Walking Category (household/most limited community walkers, least limited community walkers, and unlimited community walkers) obtained by telephone survey at 6 months post-discharge. Predictive accuracy and cut-off values for discriminating among groups were calculated from 6-minute walking distance and comfortable walking speed measured at the time of discharge using receiver operating characteristic curves. [Results] Between household/most limited and least limited community walkers, 6-minute walking distance and comfortable walking speed offered similar predictive accuracy (area under the curve, 0.6–0.7), with cut-off values of 195 m and 0.56 m/s, respectively. Between least limited and unlimited community walkers, the areas under the curve were 0.896 for 6-minute walking distance and 0.844 for comfortable walking speed, with cut-off values of 299 m and 0.94 m/s, respectively. [Conclusion] Walking endurance and walking speed among inpatients with subacute stroke provided superior predictive accuracy for unlimited community walkers at 6 months post-discharge.
Key words: 6-minute walking distance, Comfortable walking speed, Predictive validity

(This article was submitted Nov. 16, 2022, and was accepted Dec. 14, 2022)

INTRODUCTION

For patients with stroke, going out into the community plays an important role in social participation[1–3]. Improving the mobility needed to go out into the community is thus one of the main intervention goals in rehabilitation for patients with stroke[4]. A decreased frequency of community outings following stroke is perceived by many patients with stroke as a loss of an important role that had been integral in daily life[5]. For patients discharged from acute-care hospitals, 53% showed a decrease in community ambulation ability in the first month post-discharge compared to before admission, and 34% of those patients had not recovered community ambulation ability within the first 6 months post-discharge[6]. The abilities to predict

*Corresponding author. Tatsuya Igarashi (E-mail: h202c001@gunma-u.ac.jp)

future community ambulation levels of hospitalized patients and provide appropriate interventions based on these predictions are thus important to support social participation.

Exercise tolerance and walking speed are widely used in the physical therapy assessment of stroke patients. Exercise tolerance in patients with stroke is an important indicator related to quality of life[7)]. Cardiopulmonary exercise stress tests by expiratory gas analysis and 6-minute walking distance (6MWD), as a field walking test, are commonly used to assess exercise tolerance. Cardiopulmonary exercise stress tests can accurately assess exercise tolerance, but the high cost of the equipment used and the need for skilled staff can make such measurements difficult to obtain in clinical settings. The safety and feasibility of the 6MWD have been reported for patients with acute stroke[8)], and this test offers a practical and easy assessment index that does not require special equipment. The 6MWD offers a good reflection of aerobic capacity[9, 10)] and is recommended for the clinical assessment of aerobic capacity and walking endurance in adults under rehabilitation for acute neurological deficit[11, 12)]. Cross-sectional validation has also reported that the 6MWD is the best single predictive discriminant of walking activity in stroke patients[13, 14)].

Comfortable walking speed (CWS) is widely used as a predictor of community walking activity and walking handicap through cross-sectional validation[1,13–15)].

Several reports have investigated the prediction of walking ability in stroke patients[13–26)]. However, most previous reports have used the degree of functional walking independence[16–22)] and walking speed[15, 24, 25)] as predictors, and no reports appear to have described prediction of the level of ambulation in community life, which reflects more real-life walking activities in a cohort of inpatients with subacute stroke. The 6MWD and CWS, which are standardized assessment scales used for stroke patients, clarification of discrimination accuracy and cut-offs for post-discharge prognosis will contribute to the determination of appropriate goal setting and intervention plans in rehabilitation, with a view to improving social participation. The objectives of this study were to compare the predictive accuracy for community ambulation levels at 6 months post-discharge between 6MWD and CWS measured at discharge in a cohort of inpatients with subacute stroke and to establish optimal cut-offs for both rating scales.

PARTICIPANTS AND METHODS

This prospective, longitudinal, observational study investigated community ambulation levels at 6 months post-discharge. Data collection was conducted for consecutive stroke patients admitted to the general ward of a single acute-care hospital in Japan between November 2020 and October 2021. Prior to the start of this study, we registered the clinical trial with the University hospital Medical Information Network (UMIN000041997). All study protocols were approved by the ethics committees at Numata Neurosurgery and Cardiovascular Hospital (approval no. 147). The study was conducted in accordance with the Declaration of Helsinki and all patients voluntarily provided written informed consent prior to participation. This study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational studies[27)].

A total of 381 patients hospitalized for stroke and undergoing physical therapy was initially enrolled. Patients were required to meet all the following inclusion criteria: 1) age ≥20 years; 2) permission provided by a physician for evaluation; 3) diagnosis of cerebral hemorrhage or cerebral infarction; 4) motor paralysis in the lower limb on one side; and 5) ability to walk at baseline assessment, regardless of the use of a walking aid (Functional Ambulation Category (FAC) >2). Exclusion criteria were as follows: 1) difficulty understanding test contents; 2) pre-morbid modified Rankin Scale score ≥3; 3) death before baseline assessment; 4) unstable angina or myocardial infarction within 1 month prior to the index stroke; 5) infratentorial lesion; or 6) missing data required for analysis. All patients started a rehabilitation program from the day of admission or within a few days later, conducted daily for 2–3 h/day. Interventions were not controlled for in this study. The appropriate sample size for calculating the receiver operating characteristic (ROC) curve was calculated using R for Mac version 4.0.2 (R Foundation, Vienna, Austria). For each ROC curve result, assuming an area under the curve (AUC) of 0.8, power of 0.9, and the proportion of both groups as 50%, the minimum number of cases required per group was determined to be 14.

Each assessment was conducted using values from two time points, with a baseline assessment conducted within 1 week prior to discharge and a follow-up assessment conducted 6 months post-discharge.

The 6MWD and CWS were measured by a physical therapist with a thorough understanding of the evaluation procedure. The 6MWD used to assess walking endurance was measured according to American Thoracic Society (ATS) guidelines[28)]. A 30-m indoor corridor was used as the walking path, and verbal feedback according to ATS guidelines was provided every minute of walking and 10 sec before the end of the measurement. Patients were allowed to use their usual assistive devices and were instructed to walk as far as possible on the walking path during a 6-minute period. Patients were allowed to slow down or rest while leaning against a wall, but were instructed before the test to resume walking as soon as possible. Patients were also instructed to stop walking if they experienced chest pain, severe dyspnea, leg cramps, instability, or cold sweats. The reliability and validity of the 6MWD in stroke patients have been confirmed[29–31)].

To measure CWS, patients were instructed to walk a set distance of 10 m at a comfortable self-selected speed. A 3-m auxiliary path was provided at both ends of the 10-m measurement section to allow for acceleration at the beginning of the walk and deceleration at the end of the walk[29)]. A walking time of 10 m was measured with a digital stopwatch and walking speed was calculated. CWS offers a reliable and valid indicator of walking ability after a stroke[29)].

Clinical characteristics at baseline such as age, gender, body mass index, type of stroke, Charlson Comorbidity Index, discharge destination, presence or absence of solitary living, sensory disturbance, unilateral spatial neglect, aphasia, pre-morbid modified Functional Walking Category (mFWC), and Brunnstrom Recovery Stage (BRS)[32] for motor paralysis severity were investigated. In addition, Mini-Balance Evaluation Systems test[33], modified Dynamic Gait Index[34], Functional Independence Measure[35], and Falls Efficacy Scale-International[36] were collected for balance function and self-efficacy, as measures that have been shown to be related to physical activity and walking independence in stroke patients[13, 14, 22]. All measurements were performed by a physical therapist familiar with the evaluation methods.

The follow-up assessment determined community ambulation levels at 6 months post-discharge. Substantial recovery is considered possible by 3–6 months after stroke, and follow-up is therefore recommended by 6 months[37]. Follow-up assessment was conducted by telephone survey of patients by a physical therapist with a thorough understanding of the evaluation procedures. In cases where patients showed difficulty understanding assessment questions, a telephone survey was conducted with family members. Mobility and living conditions were ascertained, and a mFWC[15] was used to classify community ambulation levels into six categories: 1) physiological walkers−walks for exercise only either at home or using parallel bars during physical therapy; 2) limited household walkers−able to walk to some extent for activities at home, but may need assistance for some walking or use a wheelchair; 3) unlimited household walkers−can walk in the home, but encounters difficulty with stairs and uneven terrain and may not be able to enter and leave the house independently; 4) most-limited community walkers−able to enter and exit the house and climb up and down the curb independently, and can manage stairs to some degree; 5) least-limited community walkers−able to climb stairs and independently perform moderate community activities without assistance or the use of a wheelchair, and able to go independently to either a neighborhood store or a less crowded shopping center; and 6) unlimited community walkers−independent in all activities at home and in the community, can walk even in crowded places and on steps, and demonstrates independence in shopping centers. The mFWC has been confirmed as a valid measure for determining the effectiveness of interventions for stroke patients[26, 38].

All statistical analyses were conducted using SPSS Statistics 25.0 (IBM Corp., Armonk, NY, USA). The level of significance was set at $p<0.05$. Analyses included only those patients who completed the follow-up assessment. Descriptive statistics are reported as mean ± standard deviation or frequency for patient demographics and clinical characteristics.

To determine the relationship between level of community ambulation at 6 months post-discharge, and 6MWD, CWS, and demographic and clinical characteristics at baseline, patients were divided into three groups based on mFWC at 6 months post-discharge: household/most-limited community walkers (including the most limited community walkers from among physiological walkers); least-limited community walkers; and unlimited community walkers. Univariate analysis was performed to determine whether each variable differed among the three categories using analysis of variance for continuous variables and the Kruskal–Wallis test for ordinal variables, and the χ^2 test or Fisher's exact test for nominal variables. When a significant difference was found between the three groups, Tukey's comparison was used for continuous variables, the Dunn–Bonferroni procedure for nominal variables, and the Steel–Dwass test for ordinal variables for each multiple comparison.

Next, ROC curves were used to validate optimal cut-offs for 6MWD and CWS at discharge to predict community ambulation levels at 6 months post-discharge. Cut-offs were calculated for household/most-limited community walkers versus least-limited community walkers and least-limited community walkers versus unlimited community walkers, respectively. The prediction accuracy of variables was assessed using the AUC and its 95% confidence interval (95% CI), which can be interpreted as the probability that participants will be correctly classified into a designated group (i.e., inferior vs. superior community ambulation level groups). The strength of the AUC was determined as follows: 0.7–0.8, acceptable; 0.8–0.9, excellent; and 0.90–1.0, outstanding discriminatory power[39]. For each ROC curve, the Youden index (sensitivity + [1 − specificity]) was used to calculate the cut-off. Sensitivity, specificity, positive predictive value (PPV) and negative predictive values (NPV) were calculated using the Youden index. PPV represents the probability of a true-positive test result when the test result is positive, while NPV represents the probability of a true-negative test result when the test result is negative.

RESULTS

Figure 1 shows the flowchart of study participation. Of the 92 patients who participated in inpatient rehabilitation, 78 continued to participate in the study as of the follow-up assessment at 6 months post-discharge.

Table 1 shows demographic and clinical characteristics at the baseline assessment for patients who completed up to the follow-up assessment, grouped by community ambulation levels at 6 months post-discharge. The unlimited community walkers group was the largest, at 42, followed by least-limited community walkers (n=16) and household/most-limited community walkers (n=20; limited household walkers, n=1; unlimited household walkers, n=2; most-limited community walkers, n=17). Type of stroke, sensory disturbances, premorbid mFWC, BRS, balance function and self-efficacy indices differed significantly between groups. The mFWC from pre-morbid to follow-up was improved in 6.4%, unchanged in 51.3%, and worsened in 42.3%. No adverse events were encountered in study patients during measurements.

Table 2 shows a comparison of walking abilities at discharge by community ambulation levels at 6 months post-discharge. Mean 6MWD at discharge was 203.6 ± 91.2 m, 266.3 ± 100.4 m, and 430.1 ± 74.3 m for household/most-limited community walkers, least-limited community walkers, and unlimited community walkers, respectively, with significant differences apparent between groups. Mean CWS at discharge was 0.7 ± 0.3 m/sec, 0.9 ± 0.3 m/sec, and 1.2 ± 0.2 m/sec for household/

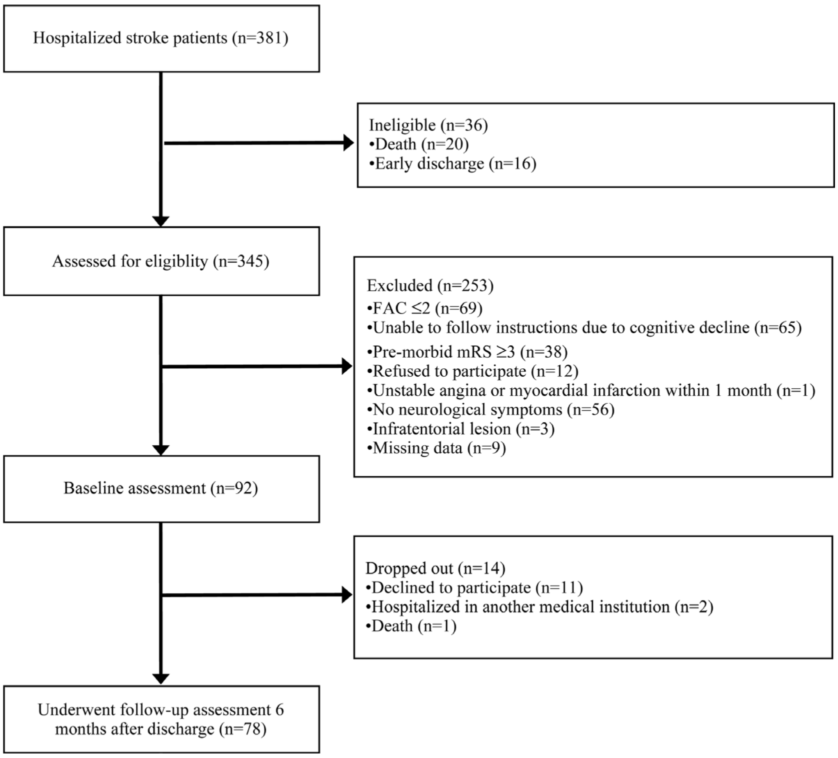

Fig. 1. Flowchart of study participants.
FAC: Functional Ambulation Category; mRS: modified Rankin Scale.

most-limited community walkers, least-limited community walkers, and unlimited community walkers, respectively, with significant differences between groups. Multiple comparisons revealed significant differences for both 6MWD and CWS at discharge between household/most-limited community walkers and unlimited community walkers and between least-limited and unlimited community walkers, but no significant difference between household/most-limited and least-limited community walkers.

Figure 2 shows ROC curves for predicting community ambulation levels at 6 months post-discharge based on walking abilities at discharge. Table 3 shows the results of cut-offs by Youden index. ROC curve analysis showed that AUCs for 6MWD and CWS between household/most-limited community walkers and least-limited community walkers were 0.672 (sensitivity 0.813, specificity 0.550) and 0.675 (sensitivity 0.938, specificity 0.500), respectively, both offering similar prediction accuracy, and with no significant difference in AUC (p=0.967). AUCs for 6MWD and CWS between least-limited community walkers and unlimited community walkers were 0.896 (sensitivity 0.976, specificity 0.750) and 0.844 (sensitivity 0.929, specificity 0.625), respectively. No significant differences in the AUCs of 6MWD and CWS were seen for discriminating between least-limited community walkers and unlimited community walkers (p=0.266). Cut-offs between household/most-limited community walkers and least-limited community walkers, and between least-limited community walkers and unlimited community walkers were 195 m and 299 m for 6MWD and 0.56 m/sec and 0.94 m/sec for CWS, respectively.

DISCUSSION

This prospective longitudinal study is the first to examine whether walking abilities at discharge can distinguish community ambulation levels at 6 months post-discharge in a cohort of inpatients with subacute stroke. Predictive accuracy between groups was similar for 6MWD and CWS as demonstrated by the ROC curves (Fig. 2), with cut-offs between household/most-limited community walkers and least-limited community walkers, and between least-limited community walkers and unlimited community walkers of 195 m and 299 m for 6MWD and 0.56 m/sec and 0.94 m/sec for CWS, respectively. These results will contribute to the development of appropriate rehabilitation goal setting and treatment decisions shared by clinicians and patients.

The 6MWD at discharge offered a good predictor of unlimited community walkers at 6 months post-discharge, supporting the findings of a cross-sectional study of walking activity among community-dwelling stroke patients[13, 14]. Motor paralysis, balance, and activities of daily living abilities are all reportedly related to walking endurance in stroke patients[40]. These abilities are thought to be comprehensively required for excellent walking endurance. The 6MWD cut-off for discriminating walking independence in subacute stroke inpatients was 304 m[41], approximating the cut-off for predicting unlimited community walkers in this study. Cardiopulmonary function and fatigue are associated with physical activity after stroke[42], and a certain threshold of endurance is required for community activities, such as walking on uneven terrain or going shopping. Stroke patients with reduced walking endurance during hospitalization may show limited walking activity and life space post-discharge, suggesting the benefits of aerobic exercise and endurance training for subacute stroke patients.

The discriminant accuracy for predicting unlimited community walkers of CWS at discharge was as good as that of 6MWD when compared by AUC and its 95% confidence interval. The cutoff for unlimited community walkers in stroke

Table 1. Patient characteristics at baseline, grouped by community ambulation levels at 6 months post-discharge

	All participants (n=78)	Household/Most-limited community walkers (n=20)	Least-limited community walkers (n=16)	Unlimited community walkers (n=42)	p-value
Age (years), (SD)	72.6 (10.8)	76.6 (9.4)	73.5 (8.1)	70.4 (11.9)	
Gender (male), n (%)	52 (66.7)	11 (55.0)	14 (87.5)	27 (64.3)	
Body mass index (kg/m^2), (SD)	24.0 (4.5)	23.7 (3.3)	24.0 (3.9)	24.2 (5.2)	
Time since stroke (days), (SD)	21.9 (10.0)	24.5 (11.0)	23.6 (10.2)	19.9 (9.1)	
Type of stroke (cerebral infarction), n (%)	65 (83.3)	16 (80.0)	10 (62.5)	39 (92.9)‡	*
Charlson Comorbidity Index, (SD)	2.7 (0.8)	2.8 (0.8)	2.7 (0.7)	2.7 (0.9)	
Solitary life, n (%)	5 (6.4)	1 (5.0)	1 (6.3)	3 (7.1)	
Sensory disturbances in the lower extremities, n (%)	11 (14.1)	6 (30.0)	2 (12.5)	3 (7.1)†	*
Aphasia, n (%)	10 (12.8)	3 (15.0)	2 (12.5)	5 (11.9)	
Unilateral spatial neglect, n (%)	5 (6.4)	0 (0.0)	1 (6.3)	4 (9.5)	
Pre-morbid mFWC, n (%)			†	†	**
Household walker	3 (3.8)	3 (15.0)	0 (0.0)	0 (0.0)	
Most-limited community walker	1 (1.3)	0 (0.0)	0 (0.0)	1 (2.4)	
Least-limited community walker	11 (14.1)	6 (30.0)	2 (12.5)	3 (7.1)	
Community walker	63 (80.8)	11 (55.0)	14 (87.5)	38 (90.5)	
BRS-lower extremity, n (%)				†‡	**
Score 3	1 (1.3)	0 (0.0)	1 (6.3)	0 (0.0)	
Score 4	2 (2.6)	2 (10.0)	0 (0.0)	0 (0.0)	
Score 5	10 (12.8)	5 (25.0)	4 (25.0)	1 (2.4)	
Score 6	65 (83.3)	13 (65.0)	11 (68.8)	41 (97.6)	
Mini-BESTest, (SD)	19.0 (6.2)	14.8 (6.4)	16.4 (6.7)	22.0 (4.1)†‡	**
mDGI, (SD)	46.1 (18.2)	29.4 (17.4)	38.5 (18.8)	56.9 (8.6)†‡	**
FES-I, (SD)	34.6 (12.7)	40.0 (10.9)	36.1 (15.2)	31.6 (11.8)†‡	*
FIM, (SD)	113.3 (13.8)	106.0 (14.1)	106.0 (17.2)	119.6 (8.1)†‡	**

*p<0.05; **p<0.01; †p<0.01 compared with Household/Most-limited community walkers; ‡p<0.01 compared with Least-limited community walkers. Using analysis of variance for continuous variables and the chi-square test or Fisher's exact test for nominal variables, and the Kruskal–Wallis test for ordinal variables. When significance was found between groups, Tukey comparison was used for continuous variables, Dunn–Bonferroni procedure for nominal variables, and Steel–Dwass test for ordinal variables for each multiple comparison.
BRS: Brunnstrom recovery stage; FES-I: Falls Efficacy Scale-International; FIM: Functional Independence Measure; mDGI: modified Dynamic Gait Index; mFWC: modified Functional Walking Category; Mini-BESTest: Mini-Balance Evaluation Systems Test; SD: standard deviation.

Table 2. Walking abilities at discharge classified by community ambulation levels at 6 months post-discharge

	All participants (n=78)	Household/Most-limited community walkers (n=20)	Least-limited community walkers (n=16)	Unlimited community walkers (n=42)	p-value
6MWD (m), (SD)	338.4 (131.7)	203.6 (91.2)	266.3 (100.4)	430.1 (74.3)†‡	**
CWS (m/sec), (SD)	1.0 (0.3)	0.7 (0.3)	0.9 (0.3)	1.2 (0.2)†‡	**

**p<0.01; †p<0.01 compared with Household/Most-limited community walkers; ‡p<0.01 compared with Least-limited community walkers. After analysis of variance, Tukey comparison was used for multiple comparisons.
CWS: comfortable walking speed; SD: standard deviation; 6MWD: 6-minute walking distance.

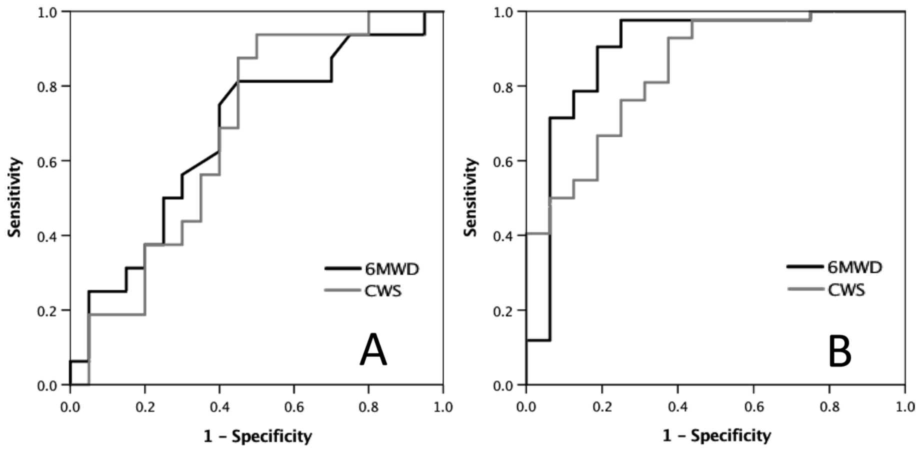

Fig. 2. Receiver-operating characteristic curves for predicting community ambulation levels at 6 months post-discharge by walking abilities at discharge.
A) Household/Most-limited community walkers (n=20) vs. Least-limited community walkers (n=16).
B) Least-limited community walkers (n=16) vs. Unlimited community walkers (n=42).
6MWD: 6-minute walking distance; CWS: comfortable walking speed.

Table 3. Optimal cut-offs and receiver operating characteristic curve analysis statistics for walking abilities at discharge predicting community ambulation levels at 6 months post-discharge

	Cut-off	Area under the curve (95% CI)	Youden index	Sensitivity	Specificity	PPV	NPV
6MWD							
Household/Most-limited community walkers vs Least-limited community walkers	195	0.672 (0.492–0.852)	0.363	0.813	0.550	0.591	0.786
Least-limited community walkers vs. Unlimited community walkers	299	0.896 (0.783–1.000)	0.726	0.976	0.750	0.911	0.923
CWS							
Household/Most-limited community walkers vs Least-limited community walkers	0.56	0.675 (0.497–0.853)	0.438	0.938	0.500	0.909	0.125
Least-limited community walkers vs. Unlimited community walkers	0.94	0.844 (0.731–0.956)	0.554	0.929	0.625	0.867	0.769

95% CI: 95% confidence interval; CWS: comfortable walking speed; 6MWD: 6-minute walking distance; PPV: positive predictive value; NPV: negative predictive value.

patients based on cross-sectional validation classified by the number of steps taken in real life has been reported as 0.93 m/sec[14]. The CWS cutoff value at discharge for discriminating unlimited community walkers in this study was 0.94 m/sec, a value that was found to approximate those of previous studies[14], even when the predictive validity was tested in the stroke cohort. Recovery of walking speed after stroke is a widely used measure of improvement in functional status. The results of this study suggest that walking speed is also useful for predicting walking activity in the community.

Multiple comparisons showed no significant differences in 6MWD and CWS at discharge between household/most-limited community walkers and least-limited community walkers at 6 months post-discharge. Comparing mean 6MWD at discharge among groups, a large difference was seen between least-limited community walkers and unlimited community walkers at 6 months post-discharge. The study included stroke patients who were able to monitor or walk independently at baseline, and the 6MWD at discharge of all patients was 338.4 ± 131.7 m, higher than that reported for subacute stroke patients in FAC2-5[41]. Both 6MWD and CWS at discharge measured among inpatients with subacute stroke appear suitable for the predictive discrimination of relatively high levels of community ambulation, but other indicators may be more suitable for predicting ambulation within and near the home.

This study had several limitations. First, sample sizes differed between groups. Significant differences were also seen between groups in type of stroke and sensory disturbances and motor paralysis in the lower extremities at discharge. Future studies should take into account such confounding factors and test generalizability. In the comparison between the least-limited community walkers and unlimited community walkers, no significant difference in AUC was detected between

6MWD and CWS, but 6MWD showed slightly higher values for sensitivity, specificity, PPV, and NPV. Because short-distance walking speed and walking endurance assess different aspects of ambulation, future studies should test external validity in larger populations. In addition, this study was conducted after the advent of a coronavirus epidemic. Many older adults were less physically active after the coronavirus epidemic than before the pandemic[43, 44], which may have affected levels of community ambulation after discharge from the hospital. However, 5.1% of all cases showed improvement at 6 months post-discharge compared to community ambulation levels prior to illness, suggesting that appropriate intervention during hospitalization and follow-up post-discharge may improve activity levels.

In conclusion, our results suggest that walking abilities at discharge offer useful predictors of community ambulation levels at 6 months post-discharge among inpatients with subacute stroke. The present findings may contribute to clinician decision-making for goal setting and intervention strategies when providing rehabilitation to patients in the subacute phase of stroke.

Funding and Conflict of interest

None.

REFERENCES

1) Lord SE, McPherson K, McNaughton HK, et al.: Community ambulation after stroke: how important and obtainable is it and what measures appear predictive? Arch Phys Med Rehabil, 2004, 85: 234–239. [Medline] [CrossRef]
2) Shumway-Cook A, Patla AE, Stewart A, et al.: Environmental demands associated with community mobility in older adults with and without mobility disabilities. Phys Ther, 2002, 82: 670–681. [Medline] [CrossRef]
3) Patla AE, Shumway-Cook A: Dimensions of mobility: defining the complexity and difficulty associated with community mobility. J Aging Phys, 1999, 7: 7–19.
4) Bohannon RW, Andrews AW, Smith MB: Rehabilitation goals of patients with hemiplegia. Int J Rehabil Res, 1988, 11: 181–184. [CrossRef]
5) Pound P, Gompertz P, Ebrahim S: A patient-centred study of the consequences of stroke. Clin Rehabil, 1998, 12: 338–347. [Medline] [CrossRef]
6) Loyd C, Beasley TM, Miltner RS, et al.: Trajectories of community mobility recovery after hospitalization in older adults. J Am Geriatr Soc, 2018, 66: 1399–1403. [Medline] [CrossRef]
7) Chen MD, Rimmer JH: Effects of exercise on quality of life in stroke survivors: a meta-analysis. Stroke, 2011, 42: 832–837. [Medline] [CrossRef]
8) Kubo H, Nozoe M, Yamamoto M, et al.: Safety and feasibility of the 6-minute walk test in patients with acute stroke. J Stroke Cerebrovasc Dis, 2018, 27: 1632–1638. [Medline] [CrossRef]
9) Boyne P, Welge J, Kissela B, et al.: Factors influencing the efficacy of aerobic exercise for improving fitness and walking capacity after stroke: a meta-analysis with meta-regression. Arch Phys Med Rehabil, 2017, 98: 581–595. [Medline] [CrossRef]
10) Moore JL, Nordvik JE, Erichsen A, et al. FIRST-Oslo Team: Implementation of high-intensity stepping training during inpatient stroke rehabilitation improves functional outcomes. Stroke, 2020, 51: 563–570. [Medline] [CrossRef]
11) MacKay-Lyons M, Billinger SA, Eng JJ, et al.: Aerobic exercise recommendations to optimize best practices in care after stroke: AEROBICS 2019 update. Phys Ther, 2020, 100: 149–156. [Medline] [CrossRef]
12) Moore JL, Potter K, Blankshain K, et al.: A core set of outcome measures for adults with neurologic conditions undergoing rehabilitation: a clinical practice guideline. J Neurol Phys Ther, 2018, 42: 174–220. [Medline] [CrossRef]
13) Fulk GD, Reynolds C, Mondal S, et al.: Predicting home and community walking activity in people with stroke. Arch Phys Med Rehabil, 2010, 91: 1582–1586. [Medline] [CrossRef]
14) Fulk GD, He Y, Boyne P, et al.: Predicting home and community walking activity poststroke. Stroke, 2017, 48: 406–411. [Medline] [CrossRef]
15) Perry J, Garrett M, Gronley JK, et al.: Classification of walking handicap in the stroke population. Stroke, 1995, 26: 982–989. [Medline] [CrossRef]
16) Smith MC, Barber PA, Stinear CM: The TWIST algorithm predicts time to walking independently after stroke. Neurorehabil Neural Repair, 2017, 31: 955–964. [Medline] [CrossRef]
17) Smith MC, Ackerley SJ, Barber PA, et al.: PREP2 algorithm predictions are correct at 2 years poststroke for most patients. Neurorehabil Neural Repair, 2019, 33: 635–642. [Medline] [CrossRef]
18) Langerak AJ, McCambridge AB, Stubbs PW, et al.: Externally validated model predicting gait independence after stroke showed fair performance and improved after updating. J Clin Epidemiol, 2021, 137: 73–82. [Medline] [CrossRef]
19) Kennedy C, Bernhardt J, Churilov L, et al.: Factors associated with time to independent walking recovery post-stroke. J Neurol Neurosurg Psychiatry, 2021, 92: 702–708. [Medline] [CrossRef]
20) Kwah LK, Harvey LA, Diong J, et al.: Models containing age and NIHSS predict recovery of ambulation and upper limb function six months after stroke: an observational study. J Physiother, 2013, 59: 189–197. [Medline] [CrossRef]
21) Veerbeek JM, Van Wegen EE, Harmeling-Van der Wel BC, et al. EPOS Investigators: Is accurate prediction of gait in nonambulatory stroke patients possible within 72 hours poststroke? The EPOS study. Neurorehabil Neural Repair, 2011, 25: 268–274. [Medline] [CrossRef]
22) Makizako H, Kabe N, Takano A, et al.: Use of the Berg Balance Scale to predict independent gait after stroke: a study of an inpatient population in Japan. PM R, 2015, 7: 392–399. [Medline] [CrossRef]
23) Mulder M, Nijland RH, van de Port IG, et al.: Prospectively classifying community walkers after stroke: who are they? Arch Phys Med Rehabil, 2019, 100: 2113–2118. [Medline] [CrossRef]
24) Ng MM, Hill KD, Batchelor F, et al.: Factors predicting falls and mobility outcomes in patients with stroke returning home after rehabilitation who are at risk of falling. Arch Phys Med Rehabil, 2017, 98: 2433–2441. [Medline] [CrossRef]
25) Louie DR, Eng JJ: Berg Balance Scale score at admission can predict walking suitable for community ambulation at discharge from inpatient stroke rehabilita-

tion. J Rehabil Med, 2018, 50: 37–44. [Medline] [CrossRef]
26) Joa KL, Kwon SY, Choi JW, et al.: Classification of walking ability of household walkers versus community walkers based on K-BBS, gait velocity and upright motor control. Eur J Phys Rehabil Med, 2015, 51: 619–625. [Medline]
27) von Elm E, Altman DG, Egger M, et al. STROBE Initiative: The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Int J Surg, 2014, 12: 1495–1499. [Medline] [CrossRef]
28) ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories: ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med, 2002, 166: 111–117. [Medline] [CrossRef]
29) 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]
30) Fulk GD, Echternach JL, Nof L, et al.: Clinometric properties of the six-minute walk test in individuals undergoing rehabilitation poststroke. Physiother Theory Pract, 2008, 24: 195–204. [Medline] [CrossRef]
31) Pohl PS, Duncan PW, Perera S, et al.: Influence of stroke-related impairments on performance in 6-minute walk test. J Rehabil Res Dev, 2002, 39: 439–444. [Medline]
32) Brunnstrom S: Motor testing procedures in hemiplegia: based on sequential recovery stages. Phys Ther, 1966, 46: 357–375. [Medline] [CrossRef]
33) Franchignoni F, Horak F, Godi M, et al.: Using psychometric techniques to improve the Balance Evaluation Systems Test: the mini-BESTest. J Rehabil Med, 2010, 42: 323–331. [Medline] [CrossRef]
34) Shumway-Cook A, Taylor CS, Matsuda PN, et al.: Expanding the scoring system for the dynamic gait index. Phys Ther, 2013, 93: 1493–1506. [Medline] [CrossRef]
35) Data management service of the Uniform Data System for Medical Rehabilitation and the Center for Functional Assessment Research: Guide for use of the Uniform Data Set for Medical Rehabilitation. version 3.1. Buffalo: State University of New York at Buffalo, 1990.
36) Yardley L, Beyer N, Hauer K, et al.: Development and initial validation of the Falls Efficacy Scale-International (FES-I). Age Ageing, 2005, 34: 614–619. [Medline] [CrossRef]
37) Meijer R, Ihnenfeldt DS, van Limbeek J, et al.: Prognostic factors in the subacute phase after stroke for the future residence after six months to one year. A systematic review of the literature. Clin Rehabil, 2003, 17: 512–520. [Medline] [CrossRef]
38) Dunsky A, Dickstein R, Marcovitz E, et al.: Home-based motor imagery training for gait rehabilitation of people with chronic poststroke hemiparesis. Arch Phys Med Rehabil, 2008, 89: 1580–1588. [Medline] [CrossRef]
39) Hosmer DW, Lemeshow S: Applied logistic regression 2nd ed. New York: Wiley, 2000.
40) Ahn SY, Lee NG, Lee TH: Relation of exercise capacity to comprehensive physical functions in individuals with ischemic stroke. NeuroRehabilitation, 2021, 48: 375–383. [Medline] [CrossRef]
41) Kubo H, Nozoe M, Kanai M, et al.: Reference value of 6-minute walk distance in patients with sub-acute stroke. Top Stroke Rehabil, 2020, 27: 337–343. [Medline] [CrossRef]
42) Thilarajah S, Mentiplay BF, Bower KJ, et al.: Factors associated with post-stroke physical activity: a systematic review and meta-analysis. Arch Phys Med Rehabil, 2018, 99: 1876–1889. [Medline] [CrossRef]
43) Yamada M, Kimura Y, Ishiyama D, et al.: The influence of the COVID-19 pandemic on physical activity and new incidence of frailty among initially non-frail older adults in Japan: a follow-up online survey. J Nutr Health Aging, 2021, 25: 751–756. [Medline] [CrossRef]
44) Yamada M, Kimura Y, Ishiyama D, et al.: Effect of the COVID-19 epidemic on physical activity in community-dwelling older adults in Japan: a cross-sectional online survey. J Nutr Health Aging, 2020, 24: 948–950. [Medline] [CrossRef]