

## A comparison of at-home walking and 10-meter walking test parameters of individuals with post-stroke hemiparesis

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**Abstract.** [Purpose] The purpose of this study was to clarify the difference in gait parameters of at-home walking and the 10-meter walking test results of individuals with hemiparesis. [Subjects] A total of 14 hemiparetic stroke recovery patients participated in this study. Inclusion criteria were: living at home, the ability to walk independently, and demonstrated low extremity on recovery stages III–V on the Brunnstrom Approach. The average age of the subjects was 66 years. [Methods] We used video surveillance and the inked footprint technique to record usual walking speed and maximum speed patterns both in subjects' homes and during the 10-meter walking test. From these methods, walking speed, stride length, and step rate were calculated. [Results] While both usual and maximum walking speeds of the 10-meter walking test correlated with stride length and step rate, at-home walking speeds only significantly correlated with stride length. [Conclusion] Walking patterns of the 10-meter walking test are quantifiably distinct from those demonstrated in patients' homes, and this difference is mainly characterized by stride length. In order to enhance in-home walking ability, exercises that improve length of stride rather than step rate should be recommended.

**Key words:** At-home walking, Stride length, Step rate

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### INTRODUCTION

Helping patients regain the ability to walk is one of the primary objectives of rehabilitation facilities, such as those in hospitals and nursing homes, during both the acute and recovery stages of stroke. Walking environments vary tremendously, however, and patients must learn to cope with many different surroundings, such as at home, in the local community, and within facilities such as hospitals and nursing homes<sup>1)</sup>.

In general, rehabilitation goals are focused on providing patients with the ability to reestablish their domestic life as the majority of strokes occur within the elderly population who no longer require occupational reintegration. Such programs are often aimed at improving patient mobility within nursing homes and assisted living residences, which can differ markedly from typical home environments, resulting in a tangible gap between realistic needs and walking capability. Although there are several robust techniques available for the analysis of the gait of patients recovering from stroke,

including dimensional motion capture systems, force plates, and electromyography techniques, most of these tools are only used for clinical research purposes. In practice, walking analysis is most commonly performed using the 10-meter walk test, a simple method that requires only a stopwatch in order to assess gait speed over a distance of 6 m.

While there is a fair degree of variation in the times reported for the 10-meter walk test<sup>2, 3)</sup>, walking speed for community ambulation is generally considered to be approximately 54 m/min<sup>4)</sup>. The 10-meter walking test has been widely used for locomotion studies involving a plethora of patient groups, such as the elderly and those with spinal cord injuries, neuromuscular diseases, and orthopedic diseases. Additional gait cycle and gait parameter analyses, step width, step length, stride length, and step rate, have often been undertaken by such studies<sup>5–7)</sup>. Patients with hemiparesis, a condition characterized by the weakening of one side of the body that is often the result of a stroke, are also commonly analyzed using these methods.

Despite its importance to patient rehabilitation, to date no direct comparison has been made between the differences in the walking demands of the home environment and those of clinical facilities. Likewise, previous research utilizing the 10-meter walk test has typically conducted testing in clinical environments and has largely ignored patients' homes as a test arena<sup>8)</sup>. In order to promote effective walking exercises that support patients' ability to remain mobile in and around their homes, at-home gait parameters need to be identified.

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**Table 1.** General characteristics of the subjects

Age (years)	66.9 ± 9.5
Gender (M/F)	11/3
Disease duration (years)	1–10
Brunnstrom stage (III, IV, V)	8/3/3
Orthosis (yes/no)	6/8

Data is expressed as means ± SD

**Table 2.** Mean walking distance, initial step angle, and number of changes in direction during the at-home walking task

Walking distance (m)	6.3 ± 1.2
Initial step angle (degrees)	71.9 ± 24.5
Number of changes in direction	2.1 ± 1.0

Data are expressed as means ± SD

**Table 3.** Usual and maximum walking speeds during the at-home and 10-meter walking tasks

Parameters	At-home walking		10-meter walking	
	Usual speed	Maximum speed	Usual speed	Maximum speed
Walking speed (m/min)	7.7 ± 2.5 <sup>‡</sup>	10.2 ± 3.7 <sup>‡</sup>	13.1 ± 5.4 <sup>‡</sup>	15.7 ± 6.0 <sup>‡</sup>
Stride length (cm)	34.1 ± 11.6	37.8 ± 16.3*	45.8 ± 11.5	48.5 ± 12.6*
Step rate (steps/min)	46.2 ± 7.2	57.4 ± 17.6*	55.4 ± 9.9	63.5 ± 13.8*

Data are expressed as means ± SD, \*:  $p < 0.05$ , ‡:  $p < 0.001$

To address this issue, we evaluated the at-home walking capability of individuals with hemiparesis and calculated their gait parameters in order to compare them with the results of the 10-meter walking test conducted in a clinical setting.

## SUBJECTS AND METHODS

A total of 14 (11 men and 3 women) hemiparetic stroke recovery patients participated in this study. Onset of the condition occurred at least one year prior to participation in the study in all cases, and inclusion criteria were: currently living at home, the ability to walk independently in the home, and absence of overt mental disease, higher brain dysfunction, or orthopedic disease. In addition, all subjects demonstrated low extremity recovery stages III–V on the Brunnstrom Approach (Table 1). The mean age of the subjects was 66.9 ± 9.5 years and all subjects voluntarily agreed to participate in this research after receiving an explanation of its purpose and content and all the risks involved. This study was conducted in accordance with the principles of the Declaration of Helsinki for experimentation with humans.

Subjects were asked to walk at their usual speed and then at their maximum speed both at home and on a 10-meter walkway in a clinical setting. For the usual speed condition, subjects were instructed to walk at a speed that was comfortable for them. For the maximum speed condition, subjects were instructed to walk as fast as they could without discomfort. For the walking test at home, subjects were asked to stand up from the sofa or chair that they usually sat on in the living room and walk to the front of the bathroom door, taking their usual route. The researcher began timing from the point the subject began walking. No assistive devices were permitted other than an ankle-foot orthosis and a cane. Walking times were measured using a digital stopwatch. The number of steps, step length, angle of initial step, and number of direction changes during walking were assessed using the inked footprint technique proposed by Shores S<sup>9)</sup> and Clarkson BH<sup>10)</sup>. After each trial, average walking speed, stride length, and step rates were calculated.

Gait parameters were compared using the paired, two-

tailed Student's t-test and a significance threshold of 0.05. The relationships between stride length and step rate and walking speed were examined using Pearson's correlation coefficient.

## RESULTS

The average distance walked during the at-home walking task was 6.3 ± 1.2 m, with 11 of the 14 subjects walking between 4 and 7 m. The angle of the initial step of the at-home walking task was 71.9° ± 1.2°, and subjects changed the direction of walking 2.1 ± 1.0 times during the exercise (Table 2).

Walking speed, stride length, and step rate of maximum walking speed were significantly greater than their values for usual walking speed both in the at-home exercise and the clinical 10-meter walking test (Table 3).

Both the usual and maximum walking speeds of at-home exercise significantly correlated with stride length, but no such correlations were found with step rate. Analysis of the clinical 10-meter walking test revealed that both usual and maximum walking speeds significantly correlated with stride length and step rate (Table 4).

## DISCUSSION

During the at-home walking task, subjects typically began their walk with a sideways step and were required to change their direction of travel several times. In addition, walking speeds during the at-home walking task were correlated only with stride length, whereas walking speeds during the clinical 10-meter walking test correlated with both stride length and step rate. These results indicate that there is a quantifiable difference between walking at home and in the 10-meter walking test in a clinical setting.

Previous studies using the 10-meter walking test have reported a comfortable walking speed range of 39–56.4 m/min and a maximum walking speed range of 78–90 m/min for individuals with hemiparesis<sup>11–13)</sup>. In contrast, our subjects had walking speed of 13.1 m/min and a maximum

**Table 4.** Spearman's correlation coefficients for stride length and step rate during at-home and 10-meter walking tasks

Parameters	At-home walking		10-meter walking	
	Usual speed	Maximum speed	Usual speed	Maximum speed
Stride length (cm)	0.913 <sup>‡</sup>	0.809 <sup>‡</sup>	0.977 <sup>‡</sup>	0.884 <sup>‡</sup>
Step rate (steps/min)	-0.214	-0.062	0.954 <sup>‡</sup>	0.772 <sup>†</sup>

Values are expressed as correlation coefficients, \*:  $p < 0.05$ , †:  $p < 0.01$ , ‡:  $p < 0.001$

walking speed of 15.7 m/min in the 10-meter walking test, indicating that they had very low walking ability. In a study utilizing the 10-meter walking test, Suzuki et al.<sup>14)</sup> reported a normal walking speed of 31.8 m/min with a maximum walking speed of 53.4 m/min, and noted that stride length and step rate increased with walking speed. In spite of the dramatically lower speeds demonstrated by our subjects, this correlation was replicated in our study, which indicates that, for individuals with hemiparesis with low walking ability who stay at home, an increase in walking speed has a significant influence on their stride length and step rate in the 10-meter walking test.

There is a large degree of variation in the types of home environment with, but the results of our study suggest that for a typical 6-m walk, individuals with hemiparesis will begin with an initial 72° angle with their first step and change direction twice. Increases in at-home walking speed only correlated with stride length whereas increases in walking speed during the 10-meter walking test correlated with both stride length and step rate. This shows that there is a distinct difference between the two settings. In the 10-meter walking test, walking patterns typically showed a straight-line walk at a constant speed that resulted in the attainment of maximum stride length. On the other hand, walking within the home was characterized by frequent acceleration and deceleration, as well as changes in direction that prevented subjects from achieving a consistent stride. Moreover, rooms at home are usually filled with furniture, meaning that there is not as much open space as in a rehabilitation room at a hospital. Although walking analysis in the hospital has long been the object of study, little attention has been given to the psychological influence of walking patterns and how these differ between the home and hospital. Hence, there is little empirical knowledge or scientific data concerning the influence of these differences. It is possible that differences in walking space affect people's motivation, give them feelings of unease, fear, or safety, and may even change their muscle tone.

The present results were obtained through examination of chronic hemiplegic individuals, whose walking ability was considerably impaired, and further studies are needed to clarify whether the results of this study are consistent with the results of hemiplegic individuals who have practiced outdoor walking, patients with gait disorders caused by other

diseases, and healthy persons.

Taken collectively, the results of this study suggest that in contrast to the ability to perform the 10-meter walking test, in order to enhance mobility at home it is necessary to try and increase stride length rather than step rate.

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