Scand J Rehab Med 29: 161–165, 1997

SELF-SELECTED WALKING SPEED IN PATIENTS WITH HEMIPARESIS AFTER STROKE

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ABSTRACT. "Self-selected walking speed" was measured in 18 patients with hemiparesis after stroke and compared with that in a healthy control group. The average speed of the patient group for a 30 m walk was 0.78 m/s (SD 0.24) and of the control group 1.69 m/s (SD 0.05). The intraindividual variation for the patients was 0.004 m/s and the interindividual variation 0.37 m/s. For the controls, the corresponding values were 0.000 m/s and 0.003 m/s, respectively. "Self-selected walking speed" correlated significantly with "functional walking test" ($r = 0.91$) and, "number of steps" ($r = 0.97$) as well as with self-assessment scores of walking ability and stiffness, the degree of motor function of the lower extremities, muscle tone and balance. The significant correlation between "self-selected walking speed" and other studied tests strengthens their validity and implies that they can be used separately or in combination to evaluate the effect of rehabilitation programmes in patients with hemiparesis after stroke.

Key words: functional tests, hemiparesis, self-assessment scales, stroke, walking speed.

INTRODUCTION

Patients with hemipareses after stroke usually undergo extensive training programmes in order to regain lost functions. Re-education of their gait is one of the most important tasks for the physiotherapist. Recovery of walking function occurs in 95% of the patients within the first 11 weeks after stroke (11).

There is now solid documentation that showing stepping movements are automatically executed on a spinal level controlled by descending "command systems" of supraspinal origin (5, 7). The "command systems" can start the stepping, increase or decrease its speed and stop it. In a hemiplegic patient, the neuronal network of the spinal gait system is partly uncontrolled. The re-organization of the system can be considered to be due to an inherent process that is not readily influenced by external means. It therefore seems that a holistic view of the restoration of gait in hemiplegic patients is more appropriate than a segmental description of local movements of the body parts in space or concomitant isolated activity, since such measures give no information about the patient's ability to co-ordinate multilinked segments to perform a purposeful task.

Although qualitative assessment might have some value for planning a treatment programme, quantitative data are necessary as outcome measures in clinical studies. Highly technical systems exist which derive quantitative data (12, 14, 16) using electromyography, electrogoniometry, video-recordings, measurement of ground reaction force, and so on, but these techniques are not usually available in the average clinic. It has also been argued that such systems provide more detailed information than is usually needed to assess the treatment outcome in most clinical settings (9).

Temporal-distance (TD) measurements including parameters such as cadence, stride length, velocity and stance time are clinically feasible and yield quantitative data, most of which have been shown to be reliable and valid (15). To measure all parameters of the TD concept is time-consuming. Velocity is considered the most appropriate of the TD parameters to measure ambulation performance (9, 18). Previous studies have shown that velocity correlates well with other aspects of walking, i.e. propensity to fall, knee muscle strength, cadence and the use of aids (2, 9, 13).

Hemiplegic patients generally walk slowly and they do not have the ability to increase their velocity without excessively increasing the energy demand (10). It has been found that when subjects are requested to walk at their self-selected, natural and most comfortable speed, they choose the speeds that require least energy (8). Therefore high speed is not a goal *per se,* but the measurement should concern the speed used in self-selected, comfortable walking.

Despite their simplicity and potential clinical usefulness, few reports of velocity measurements in hemiplegics have been published. One possible reason for the relative lack of data might be clinicians' uncertainty about whether gait speed is a sufficient measure of ambulation performance and to what extent changes in gait speed correlate with other changes of function.

The aims of the study were to investigate to what extent the walking speed differs between patients with hemiparesis and healthy subjects when they are asked to walk at a self-selected, comfortable speed, to examine whether ''self-selected speed'' is a reliable test of walking ability in patients with hemiparesis and to analyse the degree of correlation between ''self-selected speed'' and other functional tests that can be used in the study of patients with hemiparesis due to stroke.

METHODS

Subjects

Eighteen patients (8 females and 10 males) with residual hemiparesis due to stroke for at least one year participated in the study after giving their informed consent. Selected demographic and functional data are presented in Table I. Their mean age was 54 years (range 45 to 65 years). They had all undergone a period (mean 4.9, range 2.6 to 8.5 months) of formal rehabilitation at the Department of Neurological Rehabilitation at Sahlgrenska Hospital in Göteborg. The investigation started on average 4.5 months (range 3.0 to 5.2 months) after the patients' discharge from the hospital. Thus, none of the patients had received any clinically administered rehabilitation for at least 3 months before the start of the study. Seven patients had returned to their previous work, 2 planned to return, 6 were receiving disability pensions and 3 retirement pensions. All presented reduced walking ability but were capable of walking indoors, 6 of them with the use of a cane. Exclusion criteria included severe or unstable medical conditions, major perceptual disorders, marked cognitive disturbances including memory defects or other disturbances—additional to the hemiparesis—that might affect their gait.

The control group consisted of 11 healthy subjects (5 females and 6 males) with a mean age of 53 years (range 49 to 62 years).

Assessment instruments

Self-selected walking speed. The patients and control subjects walked 30 m in a corridor the central third of which was marked. They were asked to use a self-selected, comfortable walking speed. The time was measured by means of a stop-watch for both the 30 m and the central 10 m stretch. At each test, all individuals walked the 30 m 4 times with a resting interval of 2 minutes and the average velocities for the 30 m and the 10 m were calculated. The test was performed four times on each of four occasions: first at two occasions with 2-hour intervals and then after 8 days and 21 days, respectively. The tests were performed between 9 and 11 a.m. in the same room and supervised by the same examiner.

Functional walking test. The patients walked 30 m, turned round, picked up a small sandbag from the floor and walked back. They were allowed to use either hand. The time was measured by means of a stop-watch (4). The number of steps taken to walk 30 m was counted.

Self-assessment scales. The visual analogue scale (VAS) consists of a 100 mm straight line on which the patients marked their own assessments of their walking ability and joint stiffness on two scales. References were the left-hand end of the lines, which indicated ''maximally reduced walking ability'' or ''maximal stiffness'' and the right-hand end, corresponding to 100 mm, which indicated ''normal walking ability'' or ''no stiffness''.

Evaluation of motor function of the lower extremities according to Fugl-Meyer et al. (6). The evaluation included motor function, coordination and reflexes of the lower extremities, and applied a cumulative numerical score (maximal score: 34).

Balance. The patients had to stand on the affected leg for as long as possible. Ten seconds was determined to be the maximal time. The time was measured by means of a stop-watch (maximal score:10).

Functional tests of hypertonia. The patients were seated with

Table I. *Selected demographic and functional data of the patient group*

Variables	All patients ($n = 18$)	Patients without canes ($n = 12$)	Patients with canes ($n = 6$)
Female	7	5	2
Male	11	7	4
Age/years mean (range)	54 (45–65)	53 (45–65)	55 (46–65)
Type of stroke			
Haemorrhagic	7	4	3
Ischaemic	11	8	3
Hemiplegic side			
Right	6	5	1
Left	12	7	5
Months post stroke	12–14	12–14	12–14
Physical performance			
Motor function in the lower extremities (maximal score: 34) mean (SD)	23.0 (5.5)	25.6 (4.7)	17.8 (2.5)

Table II. *Functional walking test, number of steps and self-assessment of walking*

Variables	All patients (n = 18)		Patients without canes (n = 12)		Patients with canes (n = 6)	
	Mean	SD	Mean	SD	Mean	SD
Functional walking test (s/30 m)	32.9	15.6	24.9	5.3	48.9	17.5
Number of steps (30m)	56.6	11.4	50.2	3.4	69.5	10.8
Self-assessment of walking (0–100 mm)	41.8	22.4	49.5	20.5	26.3	18.8

90° flexion of the knees. Without any previous training, active extension-flexion (90°–0°–90°) and flexion-extension (120°–90°–120°) of the knees were performed as many times as possible within 10 seconds. The number was registered (3).

Statistical method

Correlations between variables were calculated by means of Spearman's rank correlation test.

RESULTS

The velocities at self-selected walking speed for the controls showed minor variation (mean value 1.69 m/s SD 0.05). The corresponding values for the patients showed a more than two times lower mean value (0.78 m/s, SD 0.24). There was no significant difference

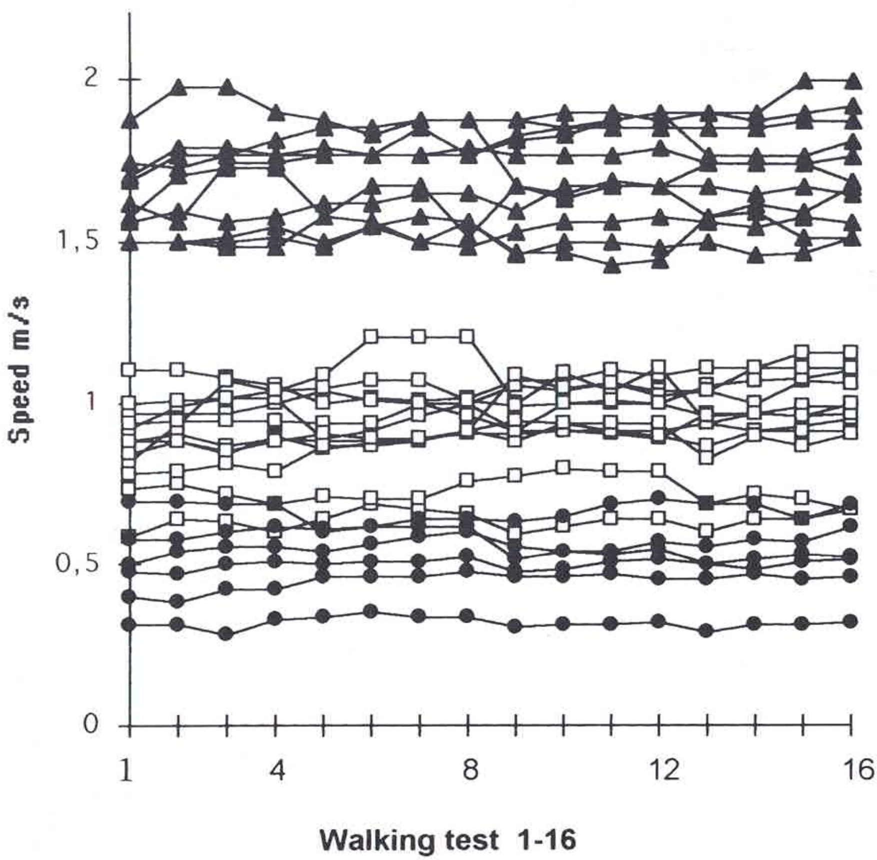

Fig. 1. Diagram illustrating the speed of the 18 patients (□, ●) and the 11 control subjects (▲) at each of the 16 walking tests. In the patient group, □ signify patients walking without canes and ● patients using canes.

Table III. *"Self-selected walking speed", 30 m and 10 m, or the controls, all patients, patients without canes and those with canes. The mean value is based on 16 measurements (4 measurements at each of the 4 walking tests). Walking speed is given as m/s*

	Controls ($n = 11$)		All patients ($n = 18$)		Patients without canes ($n = 12$)		Patients with canes ($n = 6$)	
Walking distance (m)	Mean	SD	Mean	SD	Mean	SD	Mean	SD
30	1.69	0.05	0.78	0.24	0.92	0.13	0.51	0.12
10	1.69	0.05	0.78	0.23	0.91	0.13	0.51	0.12

in the velocity between the 30-m and the central 10-m stretch (Table II). The velocity for each patient is illustrated in Fig. 1. Six patients had to use canes. The average velocity for the 6 patients using canes was 0.51 m/s (SD 0.12), as compared with 0.91 m/s (SD 0.13) for the other 12 patients. The intraindividual variation for all patients was 0.004 m/s and the interindividual variation 0.37 m/s. For the six patients using canes the intraindividual variation was 0.005 m/s and the interindividual variation 0.38 m/sm while for those not using canes the corresponding figures were 0.004 m/s and 0.04 m/s. For the controls, the intraindividual variation was 0.000 m/s and the interindividual variation 0.003 m/s.

The results of the *functional walking test, number of steps and self-assessment scale of walking* are presented in Table III. There was a significant correlation between "self-selected walking speed" and the other functional tests and self-assessment registrations on the VAS (Table IV). The level of correlation is particularly high in relation to "functional walking" ($r = 0.91$, $p < 0.001$) and "number of steps" ($r = 0.97$, $p < 0.001$).

Table IV. *Correlation between "self-selected walking speed" and other functional tests*

Variables	r_s	p
Motor function of the lower extremities	0.65	**
Balance	0.53	*
Hypertonia test 90°–0°–90° (ext–flex)	0.55	*
Hypertonia test 120°–90°–120° (flex–ext)	0.61	**
Functional walking	−0.91	***
No. of steps	−0.97	***
Stiffness (self-assessment)	0.60	**
Walking ability (self-assessment)	0.50	*

r_s = Spearman's rank correlation coefficient.
* = $p < 0.05$.
** = $p < 0.01$.
*** = $p < 0.001$.

DISCUSSION

The wide interindividual variation in walking speeds in the patient group is not surprising. The group is heterogeneous with respect to types of primary injuries, periods for recovery after the stroke and the extent of residual defects. The six patients using canes differed from the other patients in walking ability and contributed markedly to the interindivual variation in walking speed in the patient group. The retest reliability of the self-selected walking speed test was high and its validity was confirmed by the high correlation to other reliable functional tests. The presented method is easy to perform and inexpensive compared to a gait laboratory test. The presented data have practical implications: a primary goal for the training should be to reach a walking velocity of 0.91 m per second, achieved by the patients walking without canes. Self-selected walking speed should be used as an outcome measure. As such, it is easily understood and accepted by the patients. It must be noted, however, that walking speed does not facilitate diagnosis of an underlying physiological disturbance which might need special treatment. This requires the facilities of a gait laboratory.

The high correlation between "self-selected walking speed" and other functional variables studied implies that, in practical work, one functional test can be used separately or in combination with some others to evaluate the patients' functional capabilities. This is in line with other studies; for example, in correlating the walking speed of hemiplegics to their clinical status, Brandstater et al. (2) observed that the slower the patient's gait, the more severe the motor deficit. Similarly, Holden et al. (10) found that as the abnormal temporal parameters began to approximate normal values, so did other levels of function. Suzuki et al. (17) reported a significant correlation between the walking speed of hemiplegic patients and their stationary postural stability.

According to Yamada et al. (22), there is a significant correlation between preferred walking speed and the maximum walking speed in hemiparetic stroke patients. Measurement of maximum walking speed has been used to document walking capacity and to predict functional state in neurologically impaired patients, including those with stroke (19). In the choice between self-selected, most convenient walking speed and maximal walking speed as a measure of walking ability, it is possible that the self-selected most convenient speed is preferable. It is not a goal *per se* to walk fast and, moreover, it implies a certain risk of falling. Wall & Turnball (20, 21) have shown that stroke patients can improve their walking speed without any notable improvement in their walking pattern. This is considered a short-term gain. In the long run, such a forced pattern of walking will eventually result in increased spasticity and thereby reduced speed (1).

ACKNOWLEDGMENTS

The study was supported by grants from Renee Eanders Hjälpfond and Legitimerade Sjukgymnasters Riksförbund (neurology section)

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Accepted January 14, 1997.

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