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Walking training of patients with hemiparesis at an early stage after stroke: a comparison of walking training on a treadmill with body weight support and walking training on the ground

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Objective: To compare the effect of walking training on a treadmill with body weight support (BWS) and walking training on the ground at an early stage of rehabilitation in patients with hemiparesis after stroke.
Design: Randomized controlled experimental study.
Setting: Multicentre design; three departments of rehabilitation medicine.
Subjects: Seventy-three consecutive first stroke patients admitted to a rehabilitation clinic were randomized into a treatment group and a control group.
Interventions: The treatment group received walking training on a treadmill with BWS for 30 minutes, 5 days a week. The control group received walking training according to the Motor Relearning Programme (MRP) on the ground for 30 minutes 5 days a week, not including treadmill training. During the time in the rehabilitation department (about two months), all patients in the study also received professional stroke rehabilitation besides the walking training in the two groups.
Main outcome measures: Functional Independence Measure (FIM), walking velocity for 10 m, Functional Ambulation Classification (FAC), Fugl-Meyer Stroke Assessment and Berg's Balance Scale. The assessments were performed at admission, at discharge and at 10-month follow-up.

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Results: There were no statistically significant differences between the groups at discharge or at the 10-month follow-up with regard to FIM, walking velocity, FAC, Fugl-Meyer Stroke Assessment, and Berg's Balance Scale. Patients in both groups improved in these variables from admission to the 10-month follow-up.
Conclusions: Treadmill training with BWS at an early stage of rehabilitation after stroke is a comparable choice to walking training on the ground.

Introduction

The ability to walk has been stated to be one of the most important goals of rehabilitation for stroke patients (see, for instance, refs 1 and 2). Recovery of walking ability occurs in 95% of patients within the first 11 weeks after stroke. The time and the degree of recovery are related both to the degree of the initial loss of walking disability and to the severity of lower extremity paresis.[3]

The early physical therapy intervention in walking training is generally recognized as beneficial in the treatment of patients with stroke, but it is not clear what type of physical therapy programme would promote optimal recovery. Major emphasis in training for independent walking has included weight-bearing, balance and co-ordination.[4] Task-specific intensive walking training, e.g. use of a limb-load monitor, resisted exercises in the upright position with an isokinetic device and walking on a treadmill, for optimization of walking recovery in acute stroke patients has been studied by Richards *et al.*[5] in a randomized, controlled trial. It was demonstrated that walking velocity was greater in the experimental group after six weeks of training.

Walking training on a treadmill with body weight support (BWS) is intended to optimize locomotor-related sensory inputs, which may improve the timing and coordination of motor activity.[6] There is solid documentation that stepping movements are automatically executed on a spinal level controlled by descending 'command systems' of supraspinal origin. The 'command systems' can start and stop stepping, and increase or decrease its velocity.[7,8] Animal studies have shown that the adult spinal cat can attain an almost normal walking pattern after a period of locomotor training with weight support for the hindquarters, hence facilitating stepping on a treadmill.[9] The use of body weight support to facilitate walking training has been studied particularly by Barbeau and co-workers in Canada,[10–12] Hesse *et al.* in Germany[13,14] and Dobkin and Hassid *et al.* in California.[6,15]

The studies which have reported on walking training on a treadmill with BWS in patients with stroke have, however, usually been in a later stage of the rehabilitation period. Visintin *et al.*[12] reported better mobility outcomes for the experimental group (BWS with treadmill walking) when compared with the control group (walking on a treadmill with full weight) in a randomized clinical trial involving 100 patients with stroke. Hesse *et al.*,[14] using an A-B-A single-case design, have reported improved walking ability using treadmill training with BWS in chronic nonambulatory patients with hemiparesis after stroke, with a mean time of 5.7 months after stroke onset. In a pilot study, Hassid *et al.*[15] reported improved walking symmetry in patients with stroke within three months after the onset of stroke.

BWS allows walking training to be initiated very early after the brain lesion, taking advantage of the inherent flexibility of neural elements. Weight-bearing, stepping and balance are trained simultaneously while the patient is walking on the treadmill with BWS. By using walking training on a treadmill with BWS, it would seem possible to start the walking training very early in patients with stroke.

The aim of the present study was to compare the effects of walking training at an early stage of patients with hemiparesis after stroke on a treadmill with BWS and walking training on the ground with respect to walking ability, balance and sensorimotor function.

Methods

During 1995–99, 73 patients younger than 70 years and with a first stroke with residual hemiparesis after stroke, within eight weeks from the onset of stroke, were consecutively included. The patient's informed consent was obtained before the randomization procedure.

All patients who used more than 14 seconds to walk 10 metres were included, except those with heart disease, such as angina pectoris or congestive heart failure, a psychiatric illness or patients incapable of co-operating. Patients with other severe disabilities (e.g. caused by rheumatoid arthritis) that might hinder their training, as well as patients who participated in other studies, were also excluded.

The study had a multicentre design with 44 participants from the Department of Rehabilitation Medicine, Sahlgrenska University Hospital, Göteborg, 17 from the Department of Rehabilitation Medicine, Uppsala University Hospital and 12 from the Department of Rehabilitation, Lund University Hospital.

Randomization procedure

Patients were randomized into two groups by using sealed envelopes. Thirty-six patients were randomized to the treatment group and 37 patients to the control group.

Drop-outs

Five patients did not complete the study for medical reasons, two patients died and two patients refused to walk on the treadmill. One patient insisted on walking on the treadmill though randomized to the control group (Figure 1). At the 10-month control two patients had moved and one patient did not want to participate in the study. Hence, 60 patients (28 in the treatment group and 32 in the control group) completed the study.

Equipment and training procedure

The equipment for walking with BWS consisted of a standard treadmill attached to weight supporting apparatus (TR Spacetrainer™, TR Equipment AB, Tranås, Sweden). The treadmill measured 0.5 × 1.6 m and had a speed of 0–2 m/s. BWS was variable between 100% and 0% of the user's weight. The selected level of BWS was kept constant throughout the gait cycle by its following the vertical displacement of the body. To obtain BWS, the patient wore a modified mountain climber's harness with an adjustable belt around the pelvis attached at three points (one ventral, one lateral and one dorsal) to an adjustable belt around each thigh. The shoulder straps of the harness were attached to a bar whose lifting strap was fastened at a central point above the patient's head. An adjustable crossbar for hand support was mounted in front of the patient. An emergency stop button was mounted on the bar as well as on the control box. The speed and distance were monitored on a display. A wheelchair ramp could be mounted on the treadmill for patients who sat in a wheelchair and were unable to walk onto the treadmill.

The treatment group received 30 minutes of walking training five days a week on a treadmill with BWS. The physiotherapist assisted if the patient could not lift the paretic leg. For a few patients, at the beginning of the BWS training, two physiotherapists were needed to assist the patient's movements of the leg and trunk. One physiotherapist sat at the side of the treadmill manually guiding the hemiparetic leg during the swing phase and the extension at the hip and knee during the stance phase. The other physio-

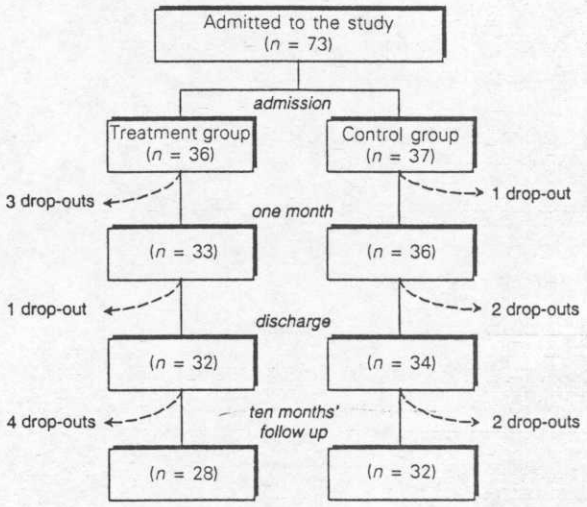

Figure 1 Flow chart describing participation in the various stages of the study.

therapist stood behind the patient to direct the movement of the pelvis and to assist, if necessary, the weight-bearing of the hemiparetic leg during the stance phase. The patients wore comfortable shoes and were allowed to take balance support on the crossbar. In some cases an ankle foot orthosis was used. No verbal instructions were given, in order to stimulate the automatic walking. The BWS was gradually reduced as fast as possible as the goal was to attain walking on the treadmill with full weight-bearing. The BWS level and walking velocity were individually chosen and were adjusted to the improvement in the patient's walking ability. To ascertain good quality of walking, the patient's walking training had to be interrupted by resting periods. The BWS training was conducted in a separate room.

The control group received individually walking training by a physiotherapist for 30 minutes five days a week. The physiotherapy approach used was according to a Motor Relearning Programme for Stroke by Carr and Shepherd.[16] The training consisted of walking on the ground and did not include training on a treadmill. For the patients who could not walk, exercises in standing were designed to allow weight-bearing on the hemiparetic leg and training to maintain appropriate segmental alignment for balance. Walking aids were used when appropriate.

The two groups spent an equal amount of time on walking training during the rehabilitation period. During another 30 minutes five days a week, both the treatment and the control group had other types of physical therapy training to improve motor control and to strengthen functionally weak muscles, such as transfers and range of motion exercises as well as techniques to improve motor function in the paretic side. Patients also practised on their own or in a group under supervision. Both groups received the same amount of treatment from the other members of the rehabilitation team. The length of the patients' stay in the rehabilitation department varied between 1 and 4 months. The treatment time for the two groups varied between 3 and 19 weeks, median 68 days in the treatment group and 66 days in the control group.

Measurement instruments

The following instruments, with established reliability and validity, were chosen to assess disability, sensorimotor function, walking and balance.

- *The Functional Independence Measure (FIM)* Manual number 4.0 of the Swedish translation was used for a team assessment[17] by trained observers. FIM consists of 13 motor and five social-cognitive items. The results are presented as sum scores for motor and social-cognitive items respectively, according to the manual. FIM has been tested for validity and reliability.[18]
- *The Fugl-Meyer Stroke Assessment* Evaluation of locomotor function and control, including balance and sensory quality, was done using the Fugl-Meyer Stroke Assessment.[19] Its reliability and validity have been confirmed by several authors (see, for instance, refs 20 and 21). The three-point ordinal scale involves direct observation of performance. The different subscales are used. In this report, an aggregated score ranging from 0 to a maximum of 226 is also reported.
- *Functional Ambulation Classification (FAC)* The amount of human assistance needed for ambulation is used for classification into six categories, from 0 = nonfunctional ambulation to 5 = ambulation-independent.[22,23]
- *Walking test* The walking test used required the patients to walk 10 metres in a corridor. They wore their preferred shoes and assistive devices were used if necessary. The time using a self-selected, comfortable walking velocity was measured by means of a stopwatch and the number of steps was counted.[24]
- *Berg's Balance Scale* The test consists of 14 items which include subjects' ability to maintain positions of varying difficulty and to perform specific tasks such as transfer between positions, reach forward and alter stance positions. Each item is scored 0–4, giving a total score of 56.[25,26]

This multicentre study has been approved by the Ethics Committees of the Faculties of Medicine at the Universities of Göteborg, Lund and Uppsala.

Measurement procedure

The measurements were performed 1–2 days after the patient's admission to the rehabilitation department. The Fugl-Meyer Stroke Assessment, FAC, walking test and Berg's Balance Scale were repeated each month, which means 2–3 times during the rehabilitation period. At discharge the measurements were performed once again. Ten months after the onset of stroke, the patient was asked to come to the rehabilitation department for a final assessment.

The assessment with the National Institute of Health Stroke Scale (NIH Stroke Scale) was performed at admission to the rehabilitation department by a physican. FIM was used for team assessment by observation during the patient's stay at the rehabilitation department. At the 10-month follow-up the assessment was made in the form of an interview by a physician. The other assessments were performed by one of three physiotherapists (one at each department) who had previously established a common understanding of the assessment criteria. All investigators were blinded with respect to the allocation of the patients after randomization. The total time for the assessment procedure was about one hour.

Statistical methods

Distributions of the variables are given as means, standard deviations (SD), medians and ranges. For comparisons between the treatment group and the control group, Fisher's nonparametric permutation test was used. Fisher's permutation test for paired observations was used to test changes over time. A value of $p < 0.05$ (2-tailed) was regarded as statistically significant.[27,28]

Results

Before treatment, there were no significant differences between the treatment group and the control group with respect to the selected patient characteristics and results from the NIH Stroke Scale. This was used as a descriptive measure of stroke severity at admission[29,30] (Table 1).

Nor did the groups differ with respect to the effect variables FIM, Fugl-Meyer Stroke Assessment, FAC, walking speed and Berg's Balance

Table 1 Characteristics of the stroke patients in the treatment and control group

	Treatment group (n = 36)		Control group (n = 37)		p-value
Sex					1.00
Female, n (%)	16	(44)	17	(46)	
Male, n (%)	20	(56)	20	(54)	
Age, years, median (range)	54	(24–67)	56	(24–66)	0.70
Diagnoses					0.20
Intracerebral haemorrhage, n (%)	11	(30)	6	(16)	
Cerebral infarction, n (%)	22	(61)	26	(70)	
Subarachnoid haemorrhage, n (%)	2	(6)	4	(11)	
Arterio-venous malformation, n (%)	1	(3)	1	(3)	
Brain lesion location					0.75
Right, n (%)	11	(31)	14	(38)	
Left, n (%)	21	(58)	18	(49)	
Brainstem/cerebellum, n (%)	4	(11)	5	(13)	
NIH Stroke Scale (0–36), median, (range)	9.5	(1–20)	8.0	(3–20)	0.42
Time post stroke at start of training, days, median (range)	22	(10–56)	17	(8–53)	0.07
Time in the rehabilitation department, days, median (range)	68	(21–137)	66	(25–137)	0.96

NIH Stroke Scale, National Institute of Health Stroke Scale.

Scale (Table 2). After treatment, no significant difference was seen between the groups at discharge and at the 10-month follow-up when comparing FIM, Fugl-Meyer Stroke Assessment, FAC, walking speed and Berg's Balance Scale (Table 3).

In within-group comparisons, both the treatment group and the control group had improved

Table 2 Selected variables with regard to motor performance, walking and balance of the 73 patients at admission. The maximum and minimum scores are given in parentheses

	Treatment group (n = 36)				Control group (n = 37)			
	Mean	SD	Median	Range	Mean	SD	Median	Range
FIM								
Motor items (13–91)	53.7	17.7	54.0	13–88	56.1	18.0	57.0	17–86
Cognitive items (5–35)	24.7	9.2	26.0	5–35	25.8	8.0	28.0	9–35
Fugl-Meyer Stroke Assessment								
Total score (0–226)	150.4	36.0	141.0	94–210	148.8	36.8	139.0	91–219
Upper extremity (0–66)	24.8	22.2	13.0	0–63	22.1	22.2	10.0	4–63
Lower extremity (0–34)	17.4	9.2	17.5	0–32	17.0	9.0	18.0	4–34
Balance (0–14)	7.6	3.1	8.0	0–12	7.5	2.6	8.0	2–11
Sensation (0–24)	17.1	7.7	20.0	0–24	18.3	7.7	22.0	0–24
Passive range of motion (0–44)	42.2	2.0	42.5	36–44	42.2	2.1	43.0	35–44
Joint pain (0–44)	42.3	1.9	43.0	38–44	42.2	2.0	42.0	35–44
FAC (0–5) median, range	–	–	0	0–5	–	–	0	0–4
Walking speed (m/s)[a]	0.4	0.2	0.4	0.1–0.7	0.4	0.2	0.4	0.1–1.0
Berg's Balance Scale (0–56)	23.9	19.3	23.5	0–54	23.3	16.3	25.0	0–51

[a]For walking speed n = 18 in the treatment group and n = 19 in the control group, the rest could not walk 10 m.
FIM, Functional Independence Measure; FAC, Functional Ambulation Classification.

Table 3 Selected variables with regard to motor performance, walking and balance of the 60 patients at 10 months' follow-up

	Treatment group (n = 28)				Control group (n = 32)			
	Mean	SD	Median	Range	Mean	SD	Median	Range
FIM								
Motor items (13–91)	81.9	9.6	86.5	57–90	80.3	15.9	86.0	18–91
Cognitive items (5–35)	32.0	5.0	34.0	18–35	31.5	6.6	35.0	7–35
Fugl-Meyer Stroke Assessment								
Total score (0–226)	175.5	36.9	183.5	108–226	177.6	41.0	191.1	88–221
Upper extremity (0–66)	37.6	23.0	36.5	7–66	39.4	23.8	47.0	2–66
Lower extremity (0–34)	25.4	5.9	26.5	16–34	25.3	7.6	26.0	4–34
Balance (0–14)	11.1	2.2	11.0	5–14	11.5	3.3	12.0	5–24
Sensation (0–24)	19.6	5.8	22.5	4–24	20.4	5.6	23.0	2–24
Passive range of motion (0–44)	40.8	4.2	42.0	24–44	41.4	2.1	41.0	35–44
Joint pain (0–44)	41.2	4.2	42.0	22–44	40.4	6.7	41.0	6–44
Walking speed (m/s)	0.7	0.3	0.6	0.2–1.1	0.8	0.4	0.8	0.0–1.6
Berg's Balance Scale (0–56)	48.3	11.1	53.0	16–56	47.8	13.2	52.5	4–56

FIM, Functional Independence Measure.

significantly between admission and discharge with respect to FIM, Fugl-Meyer Stroke Assessment, FAC, walking speed and Berg's Balance Scale (Table 4). Walking velocity improved significantly in both groups from admission to 10-month follow-up (Tables 2 and 3). At one month, 28 patients in the treatment group walked 10 m with a mean velocity of 0.5 m/s (SD 0.3), while five patients could not walk 10 m. In the control group, 31 patients walked 10 m with a mean velocity of 0.5 m/s (SD 0.3), while five patients could not walk 10 m. At discharge, the mean walking velocity of the 31 patients in the treatment group was 0.6 m/s (SD 0.4), and one could not walk. In the control group, the mean walking velocity of the 32 patients was 0.6 m/s (SD 0.3), and two could not walk 10 m.

The patients who could not walk 10 m at admission improved at the same rate in the treatment group and the control group with respect to motor performance and balance (Table 5).

Balance, measured by Berg's Balance Scale, improved in the treatment group from a median of 23.5 points (0–51) at admission to 40.0 points (4–56) at one month, 50.0 points (10–56) at discharge and 53.0 points (16–56) at follow-up. The results for the control group were 25.0 points (0–51) at admission, 45.0 points (5–55) at one month, 50.5 points (5–56) at discharge and 52.5 points (4–56) at follow-up.

At admission, the FAC showed that 21 patients (60%) in the treatment group and 19 patients (51%) in the control group could not walk independently. Ten months after the onset of stroke, three patients (11%) in the treatment group and three patients (9%) in the control group could not walk independently (Figure 2).

In the treatment group, BWS was gradually reduced. Initially 21 (64%) of the patients in the treatment group were using 30–64% BWS. At the start of week 4, 5 patients (17%) used 30–40% BWS and at discharge 22 patients (73%) had no BWS when training on the treadmill (Figure 3). At one month 14 patients (47%) in the treatment group used no BWS and practised supervised treadmill training. The mean velocity on the treadmill after the first week for the 32 patients in the treatment group was 0.2 m/s (SD 0.1), with a mean walking distance of 167.0 m (SD 118.8). After four weeks, the mean velocity was 0.4 m/s (SD 0.2), with a mean walking distance of 452.0 m (SD 353.3) and after eight weeks the mean velocity was 0.4 m/s (SD 0.2) for 18 patients, with a walking distance of 507.0 m (SD 344.3).

Discussion

This study performed at an early stage in patients with stroke did not demonstrate any significant outcome differences in walking ability, balance or sensorimotor performance between walking training on a treadmill with BWS compared with walking training on the ground. Both groups improved to an equal extent after treatment with respect to these variables.

It is naturally difficult to evaluate to what extent the improved walking ability is due to the treatment programmes or to spontaneous recovery, as no control group without walking training could be used on clinical and ethical grounds. Clinical data are strongly in favour of early mobilization and training, but no study has shown to what extent the beneficial effect is due to specific rehabilitation strategies.[31] The present study demonstrated the possibility of starting walking training with BWS at a relatively early stage after stroke. Thus, after staying in the acute ward (stroke unit) for a median of 19 days, the patients in the present study were transferred to the rehabilitation department. Half of the patients in both groups could not walk 10 m and had considerably impaired balance and sensorimotor functions.

In the present study, the median age of the patients at admission to the rehabilitation department was 55 (range 24–67) years. According to the organization of rehabilitation at the hospitals, patients younger than 65 years of age are usually

Clinical messages

- Walking training on a treadmill with BWS and walking training on the ground are comparable choices early in rehabilitation of patients after stroke.
- The patients improved their walking velocity, motor performance and balance in both groups.

Table 4 Differences between admission and discharge and admission and 10 months' follow-up respectively for variables with regard to motor performance, walking and balance in the treatment group and the control group

	Admission–Discharge								Admission–10 months' follow-up							
	Treatment group (n = 32)				Control group (n = 34)				Treatment group (n = 28)				Control group (n = 32)			
	Mean	SD	Median	p-level	Mean	SD	Median	p-level	Mean	SD	Median	p-level	Mean	SD	Median	p-level
FIM																
Motor items (13–91)	25.1	14.5	25.0	***	20.8	12.4	21.0	***	28.6	17.8	23.0	***	25.0	16.2	27.0	***
Cognitive items (5–35)	4.2	4.9	4.0	***	4.1	4.8	2.5	***	5.9	7.0	5.0	***	6.5	7.2	8.0	***
Fugl-Meyer Stroke Assessment																
Total score (0–226)	22.0	19.8	16.5	***	22.1	20.8	19.0	***	27.3	23.6	22.0	***	27.5	26.7	24.5	***
Upper extremity (0–66)	11.1	12.4	7.0	***	12.0	13.5	7.0	***	14.4	12.8	9.0	***	17.0	16.9	9.0	***
Lower extremity (0–34)	7.4	7.2	5.5	***	7.0	5.8	7.0	***	8.6	7.8	7.0	***	8.2	6.4	7.0	***
Balance (0–14)	3.4	2.8	3.0	***	2.6	2.7	2.0	***	3.7	3.0	3.0	***	3.9	3.0	4.0	***
Sensation (0–24)	2.5	3.5	1.0	***	2.7	5.6	0.0	0.008	2.5	4.2	1.0	0.002	1.6	4.6	0.0	0.070
Passive range of motion (0–44)	−1.5	2.3	−1.5	0.001	−1.2	2.5	−1.0	0.008	−1.3	4.0	0.0	0.083	−1.0	2.3	−1.0	0.023
Joint pain (0–44)	−1.8	2.3	−2.0	***	−1.0	2.4	−1.0	0.021	−1.0	3.9	0.0	0.187	−2.0	6.3	−1.0	0.034
FAC (0–5)	2.8	1.5	3.0	***	2.6	1.6	3.0	***	3.3	1.7	3.5	***	3.3	1.6	4.0	***
Walking m/s[a]	0.4	0.3	0.3	***	0.3	0.3	0.2	***	0.5	0.2	0.5	***	0.4	0.3	0.4	***
Berg's Balance Scale (0–56)	23.6	17.0	21.5	***	21.0	14.1	17.5	***	24.6	17.4	21.0	***	24.3	14.6	19.0	***

[a]For walking speed n = 14 in treatment group and n = 16 in control group.
p-values for the differences are shown, ***$p < 0.001$.
FIM, Functional Independence Measure; FAC, Functional Ambulation Classification.

Table 5 Results of the motor performance and balance at admission, discharge and 10 months' follow-up for the patients who could not walk 10 m at admission

	Admission					
	Treatment group (n = 18)			Control group (n = 18)		
	Mean	SD	Range	Mean	SD	Range
Fugl-Meyer Stroke Assessment						
Total score (0–226)	126.6	22.9	94–182	128.7	27.1	91–192
Upper extremity (0–66)	11.1	10.8	0–36	11.9	15.7	4–60
Lower extremity (0–34)	10.8	7.1	0–28	12.8	7.9	4–28
Balance (0–14)	5.6	2.5	0–9	5.9	2.5	2–10
Berg's Balance Scale (0–56)	11.0	12.0	0–36	11.3	11.5	0–40
	Discharge					
	Treatment group (n = 17)			Control group (n = 16)		
	Mean	SD	Range	Mean	SD	Range
Fugl-Meyer Stroke Assessment						
Total score (0–226)	158.7	33.1	116–226	150.6	37.2	88–215
Upper extremity (0–66)	24.9	20.4	4–66	21.2	21.5	4–61
Lower extremity (0–34)	23.1	5.6	17–34	21.3	7.5	4–31
Balance (0–14)	10.6	1.7	8–14	9.4	2.9	4–14
Berg's Balance Scale (0–56)	44.0	13.0	14–56	40.9	16.7	5–56
	10 months' follow-up					
	Treatment group (n = 14)			Control group (n = 16)		
	Mean	SD	Range	Mean	SD	Range
Fugl-Meyer Stroke Assessment						
Total score (0–226)	163.2	34.7	122–226	152.9	42.9	88–221
Upper extremity (0–66)	28.4	21.8	7–66	24.3	22.3	2–62
Lower extremity (0–34)	23.7	5.7	17–34	22.4	8.6	4–34
Balance (0–14)	10.6	2.2	5–14	10.1	2.8	5–14
Berg's Balance Scale (0–56)	46.0	11.6	20–56	43.2	17.3	4–56

treated in the Department of Rehabilitation Medicine, whereas older patients are treated in the Department of Geriatric Medicine. Only patients referred to the Department of Rehabilitation Medicine took part in the study. Thus, the patients in the present study are younger than most other stroke studies. FIM was used to generally describe the patients in the study and not only as an outcome measure. In a Swedish study by Grimby *et al.*,[32] the mean FIM score for motor items at admission to the rehabilitation department was 62.0 and at discharge 77.0 for 101 stroke patients. The FIM motor scores at admission were slightly lower in the present study (53.7 and 78.2 in the treatment group and 56.1 and 76.4 in the control group) and improved to a similar level as in the previous Swedish report.[32] There were no differences in mean cognitive items between the present group of patients and those in the previous Swedish report.[32]

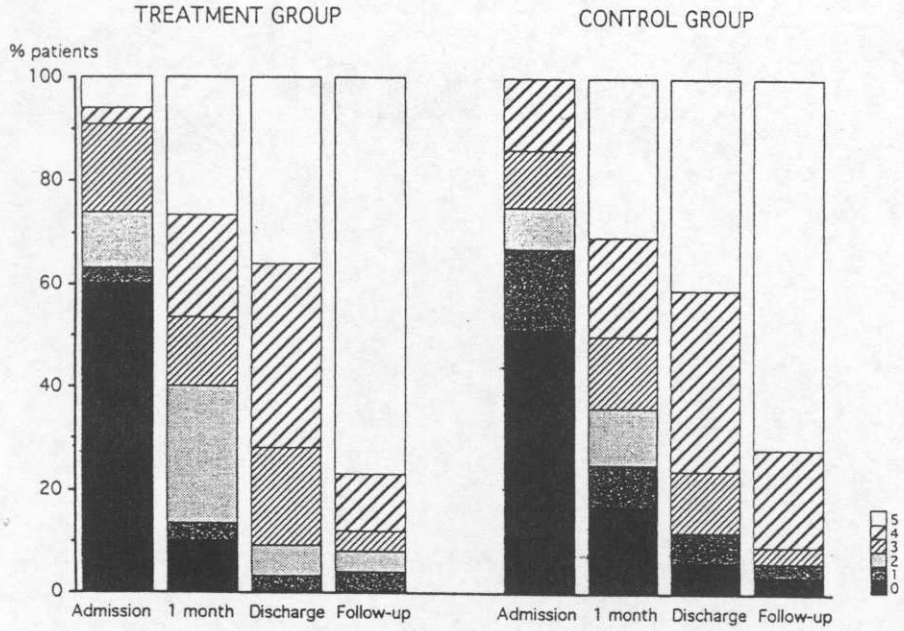

Figure 2 Distribution of Functional Ambulation Classification (FAC) at admission, one month, at discharge and at the 10-month follow-up. 0 indicates nonfunctional ambulation, 5 indicates independent ambulation.

The same treatment time was used in the control group for walking activities on the floor as in the treatment group on the treadmill. However, it was difficult to fully use the time properly for patients in the control group with marked walking problems. It is obvious that patients in the treadmill group could train more intensively without getting too tired, but this evidently did not influence the outcome. The training in both groups started three weeks after stroke onset and was intensive, performed over a mean of 10 weeks, as compared with training for six weeks in the Canadian study.[12] According to Richards *et al.*,[5] the intensity of training is most important. Treadmill training with BWS after stroke appears beneficial for severely disabled patients because it provides an opportunity to perform a large amount of practice with many repetitions of complete gait cycles. Treadmill training may also be beneficial because the motion of the treadmill enforces an appropriate timing relation between the lower limbs and ensures the extension of the hips during the stance phase. Both functions are considered to be critical biomechanical components of walking.[33,34] Danielsson and Stibrant Sunnerhagen[35] reported in a study of patients with stroke that oxygen uptake was reduced when the patients walked with 30% BWS, compared with unsupported walking. The clinical implication is that BWS decreases the oxygen demand during treadmill walking and thus energy cost and cardiovascular demands do not limit the use of treadmill training with BWS compared with conventional treadmill training.

In the present study, the median time at the rehabilitation department was 67 days (10 weeks). Most of our patients continued to improve their walking function up to the 10-month follow-up. However, already one month after start, 14 patients (47%) in the treatment group could walk on treadmill unsupported, but there was no difference in the walking speed or FAC between the two groups. It is notable that at discharge 22 patients (71%) in the treatment group and 26 patients (76%) of the control group were independent walkers while at the 10-month follow-up 24 patients (89%) and 29 patients (91%) respectively were independent walkers.

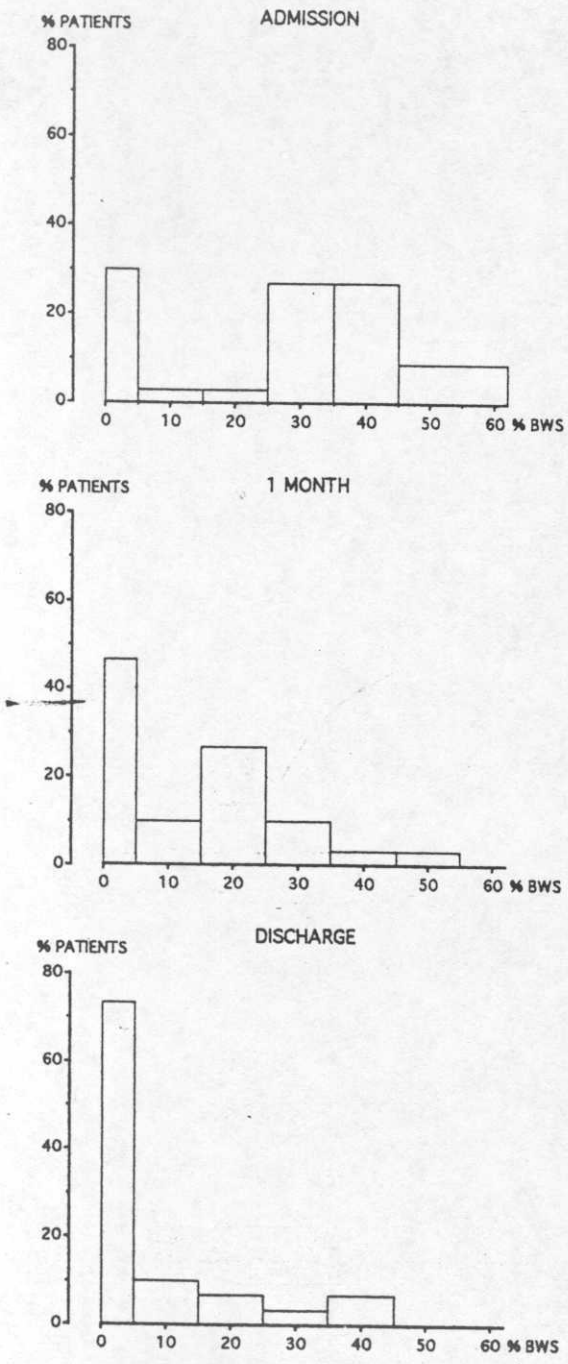

Figure 3 Distribution of % body weight support (BWS) in the treatment group provided during the first day of training (admission), the first day of the fourth week (one month) and the last day of training (discharge).

The Copenhagen Stroke Study[3] showed that recovery of walking function occurs in most patients within 11 weeks from the stroke onset. In their study, 80% of the patients reached their best walking function within the first five weeks after stroke onset.[3,36] Thus, compared with the unselected acute stroke patients in the Copenhagen Stroke Study,[3,36] the recovery of walking was slower in the present study. This can be explained by the fact that the patients in our study were selected with respect to rehabilitation problems and need for a prolonged period of inpatient rehabilitation. Mayo *et al.*[37] also stated that most of the improvement in measures of impairment and disability occurred during the first month, but 85% of their patients with stroke still had reduced walking velocity at three months.

We conclude that the two different methods used in this study, walking training on the ground and training on a treadmill with BWS, are comparable choices at an early stage in patients with stroke. Discrepancies in results between our study and earlier published studies might be due to the selection of patients, the length of the training programme as well as the amount, type and intensity of the training in the control group.

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References

1 Bohannon RW, Horton MG, Wikholm JB. Importance of four variables of walking to patients with stroke. *Int J Rehabil Res* 1991; **14**: 246–50.

2 Richards CL, Malouin F, Dean C. Gait in stroke. Assessment and rehabilitation. *Clin Geriatr Med* 1999; **15**: 833–55.

3 Jörgensen HS, Nakayama H, Raaschou HS, Olsen TS. Recovery of walking function in stroke patients: The Copenhagen stroke study. *Arch Phys Med Rehabil* 1995; **76**: 27– 32.

4 Carr J, Shepherd R. *Neurological rehabilitation: optimizing motor performance*. Oxford: Butterworth Heinemann, 1998.

5 Richards CL, Malouin F, Wood-Dauphinée S, Williams JI, Bouchard J-P, Brunet D. Task-specific physical therapy for optimization of gait recovery in acute stroke patients. *Arch Phys Med Rehabil* 1993; **74**: 612–20.

6 Dobkin BH. An overview of treadmill locomotor training with partial body weight support: a neurophysiologically sound approach whose time has come for randomized clinical trials. *Neurorehabil Neural Repair* 1999; **13**: 157–65.

7 Grillner S, Wallén P. Central pattern generators for locomotion, with special reference to vertebrates. *Annu Rev Neurosci* 1985; **8**: 236–61.

8 Finch L, Barbeau H. Hemiplegic gait: new treatment strategies. *Physiother Can* 1986; **38**: 36–41.

9 Barbeau H, Rossignol S. Recovery of locomotion after chronic spinalization in the adult cat. *Brain Res* 1987; **412**: 84–95.

10 Norman K, Pepin A, Ladouceur M, Barbeau H. A treadmill apparatus and harness support for evaluation and rehabilitation of gait. *Arch Phys Med Rehabil* 1995; **76**: 772–78.

11 Barbeau H, Norman K, Fung J, Visintin M, Ladouceur M. Does neurorehabilitation play a role in the recovery of walking in neurological populations? *Ann NY Acad Sci* 1998; **16**: 377–92.

12. Visintin M, Barbeau H, Korner-Bitensky N, Mayo N. A new approach to retrain gait in stroke patients through body weight support and treadmill stimulation. *Stroke* 1998; **29**: 1122–28.

13 Hesse S, Konrad M, Uhlenbrock D. Treadmill walking with partial body weight support versus floor walking in hemiparetic subjects. *Arch Phys Med Rehabil* 1999; **80**: 421–27.

14 Hesse S, Bertelt C, Jahnke MT *et al.* Treadmill training with partial body weight support compared with physiotherapy in nonambulatory hemiparetic patients. *Stroke* 1995; **26**: 976–81.

15 Hassid E, Rose D, Commisarow J, Guttry M, Dobkin B. Improved gait symmetry in hemiparetic stroke patients induced during body weight-supported treadmill stepping. *J Neuro Rehabil* 1997; **11**: 21–26.

16 Carr J, Shepherd R. *A motor relearning programme for stroke*, second edition. Oxford: Heinemann Medical Books, 1990.

17 *Guide for the uniform set for medical rehabilitation (adult FIM™), version 4.0* (Swedish version 1994). Buffalo: State University of New York at Buffalo, 1993.

18 Deutsch A, Braun S, Granger C. The Functional Independence Measure (FIM^{SM} Instrument) and the Functional Independence Measure for children (WeeFIM^{R} Instrument): ten years of development. *Crit Rev Phys Rehabil Med* 1996; **8**: 267–81.

19 Fugl-Meyer AR, Jääskö L, Leyman I, Olsson S, Steglind S. The post-stroke hemiplegic patient. 1. A method for evaluation of physical performance. *Scand J Rehabil Med* 1975; **7**: 13–31.

20 Sanford J, Moreland J, Swanson LR, Stratford PW, Gowland C. Reliability of the Fugl-Meyer assessment for testing motor performance in patients following stroke. *Phys Ther* 1993; **73**: 447–54.

21 Dettman MA, Linder MT, Sepic SB. Relationships among walking performance, postural stability, and functional assessments of the hemiplegic patient. *Am J Phys Med* 1987; **66**: 77–90.

22 Holden MK, Gill KM, Magliozzi MR, Nathan J, Piehl-Baker L. Clinical gait assessment in the neurologically impaired: Reliability and meaningfulness. *Phys Ther* 1984; **64**: 35–40.

23 Holden MK, Gill KM, Magliozzi MR. Gait assessment for neurologically impaired patients: Standards for outcome assessment. *Phys Ther* 1986; **66**: 1530–39.

24 Wade DT, Wood VA, Heller A, Maggs J, Hewer RL. Walking after stroke: Measurement and recovery over the first 3 months. *Scand J Rehabil Med* 1987; **19**: 25–30.

25 Berg K, Wood-Dauphinée S, Williams JI, Gayton D. Measuring balance in the elderly: Preliminary development of an instrument. *Physiother Can* 1989; **41**: 304–11.

26 Berg K, Wood-Dauphinée S, Williams JI. The balance scale: Reliability assessment with elderly residents and patients with an acute stroke. *Scand J Rehabil Med* 1995; **27**: 27–36.

27 Bradley JV. *Distribution-free stastistical tests*. London: Prentice-Hall, 1968: 76–80.

28 Good P. *Permutation test. A practical guide to resampling methods for testing hypotheses*. New York: Springer 2000: 36–37.

29 Brott T, Adams HP, Olinger CP *et al.* Measurements of acute cerebral infarction: a clinical examination scale. *Stroke* 1989; **20**: 864–70.

30 Goldstein LB, Bertels C, Davis J. Interrater reliability of the NIH stroke scale. *Arch Neurol* 1989; **46**: 660–62.

31 Johansson BB. Brain plasticity and stroke rehabilitation. The Willis lecture. *Stroke* 2000; **31**: 223–30.

32 Grimby G, Gudjonsson G, Rodhe M, Stibrant Sunnerhagen K, Sundh V, Östensson M-L. The Functional independence measure in Sweden: experience for outcome measurement in rehabilitation medicine. *Scand J Rehabil Med* 1996; **28**: 51–62.

33 Winter DA. *The biomechanics and motor control of human gait: normal, elderly and pathological*, second edition. Waterloo: University of Waterloo Press, 1991.

34 Olney SJ, Griffin MP, Monga TN, McBride ID. Work and power in gait of stroke patients. *Arch Phys Med Rehabil* 1991; **72**: 309–14.

35 Danielsson A, Stibrant Sunnerhagen K. Oxygen consumption during treadmill walking with and without body weight support in patients with hemiparesis after stroke and in healthy subjects. *Arch Phys Med Rehabil* 2000; **81**: 953–57.

36 Jörgensen HS, Nakayama H, Raaschou HO, Pedersen PM, Hout J, Olsen TS. Functional and neurological outcome of stroke and the relation to stroke severity and type, stroke unit treatment, body temperature, age, and other risk factors: the Copenhagen stroke study. *Top Stroke Rehabil* 2000; **6**: 1–19.

37 Mayo NE, Wood-Dauphinée S, Ahmed S *et al.* Disablement following stroke. *Disabil Rehabil* 1999; **21**: 258–68.