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# Rehabilitation interventions to improve locomotor outcome in chronic stroke survivors: A prospective, repeated-measure study

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» Abstract

**Objective:** To ascertain whether rehabilitation interventions improve locomotion beyond 6 months post stroke.
**Site:** The Neurological Rehabilitation Department of a university tertiary research hospital.
**Study Design:** Prospective, repeated-measure study.
**Patients:** Patients with first episode of supra-tentorial stroke of more than 6 months duration.
**Intervention:** Twenty sessions of task-specific interventions consisting of lower limb resistive exercises and treadmill gait training to locomotor abilities (90 min/day, 5 days/week for 4 weeks). Evaluations were performed at the beginning and end of training and at a follow-up of 3 months.
**Outcome Measures:** Stroke severity (Scandinavian Stroke Scale - SSS), balance (Berg Balance scale - BBS), ambulation (Functional Ambulation Category), walking ability (speed 10-m walk test - WS) and functional ability (Barthel Index - BI).
**Results:** Forty patients (32 men and eight women; age range: 22-65 years; mean post-stroke duration of 18.90 ± 12.76 months) were included in the study. Thirty-two (80.0%) patients completed their training and 28 (70.0%) patients reported at a follow up of 3-months. At the beginning, the end of training and at follow-up, the mean SSS scores were 41.71, 44.09, and 43.96; the BBS scores were 36.28, 46.75 and 46.82; the WS scores were 0.41, 0.53 and 0.51; and the BI scores were 77.34, 89.06 and 92.32, respectively. All outcome measures showed statistically significant improvement ($P < 0.001$) at the end of training and at follow-up.
**Conclusion:** Rehabilitation interventions significantly improve locomotor outcome even in the chronic phase following a stroke.

**Keywords:** Chronic stroke; disability; gait training; locomotor outcome; motor recovery; rehabilitation

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## » Introduction

Stroke is a major cause of locomotor disability in adults. Rehabilitation interventions aim to optimize the performance of activities of daily living (ADL) in chronic stroke survivors; however, on discharge, many individuals are still significantly disabled. [1],[2] Most stroke survivors can walk independently, but only a small proportion can walk with sufficient speed and endurance to enable them to function within the community. The persistent disability and handicap experienced by them arises not only from the impairments resulting from stroke but also from the deleterious neural, muscular, psychological and cardiovascular adaptations that accompany disuse as well as the use of maladaptive behaviors. [3]

The absence of ongoing activity programs after discharge from the stroke unit may be a major limitation of stroke management that may exacerbate disability and handicap. It has been found that most recovery of function occurs in the first 3 months following a stroke. [4],[5],[6] There is growing evidence to demonstrate that, with supervised training, chronic stroke survivors can improve performance of functional tasks; [7],[8],[9] however, the improvements gained are not sustained after cessation of treatment. [10],[11] Locomotor training that incorporates high repetitions of task-oriented practice may be a useful intervention in improving walking capacity in chronic stroke survivors. [12],[13],[14],[15],[16],[17],[18],[19],[20],[21],[22],[23],[24] Some earlier studies have suggested improvement in gait parameters with other measures like over ground training, [25],[26],[27],[28],[29] treadmill training [30],[31],[32] and transcranial magnetic stimulation. [33] Majority of the these studies were focused primarily on improvement in gait parameters; [7],[8],[9],[12],[13],[14],[15],[16],[17],[18],[19],[20],[21],[22] however, there is a need to simultaneously evaluate multiple dimensions of locomotion such as functional disability, balance and qualitative and quantitative measures of walking, and independence in performance of ADL.

The objective of this study was to investigate the efficacy of rehabilitation interventions aimed at improving the performance of locomotor-related tasks in chronic stroke survivors discharged from stroke units on multiple outcome measures of walking ability, balance, functional disability and independence in performance of ADL.

## » Materials and Methods

This prospective study was conducted in the Department of Neurological Rehabilitation of a university tertiary care research hospital. Recruitment was performed through the outpatient service of the department and all chronic stroke survivors attending the outpatient clinics were screened. Those fulfilling the inclusion criteria and willing to participate were included in the study.

Patients with first-ever supra-tentorial stroke, with an age range of 16-65 years, with more than 6 months of post-stroke duration, with an ability to follow three-step commands, and having an impaired balance and gait with an intact ability to walk with or without support (Functional Ambulation Category, FAC: II-IV), [35] were included in the study. Patients with recurrent strokes, bilateral hemispheric, cerebellar or brain stem lesions, receptive aphasia, significant cognitive deficits or depression, significant visual field deficits and orthopedic problems affecting participation were excluded. The protocol was approved by the Institute Ethics Committee and informed consent was obtained prior to training.

### Training strategy

All patients underwent rehabilitation interventions focused on improving the performance and endurance of functional tasks involving the lower extremities: Lower limb strengthening with resistive exercises, treadmill training, spasticity reducing exercises, reaching in sitting and standing, balance and gait training, stair ascent and descent functional abilities, and ADL training. Training was conducted for a total of 20 sessions (90 min/day, 5 days/week for 4 weeks).

### Data analysis

Data were collected at the beginning of the study (pre-training), at the end of 20 training sessions (post-training) and at 3 months of follow-up. Trained physicians, who were not part of the treating team, carried out assessments. The analysis was performed on SPSS 13.0 using paired *t* test for continuous variables and

Wilcoxon's Sign Rank test for ordinal variables at the end of training and at 3 months of follow-up.

### Outcome measures

Socio-demographic and clinical information were obtained in a pre-designed format. Effects of training were evaluated on primary outcome measures of walking ability and secondary measures of balance, disability and independence in ADL. The primary quantitative measure of walking ability was over ground walking speed (WS) and the qualitative measure of walking was FAC. [34],[35] The secondary measures used were Berg Balance Scale (BBS) for balance, [36],[37] Scandinavian Stroke Scale (SSS) [38] for severity of stroke and Barthel Index (BI) [39],[40] for independence in ADL.

### FAC

It distinguishes six levels of support required during gait without taking into consideration any aid used. It is based on a walking distance of 15 m. This has been validated for classifying walking handicap after stroke. [34] The test is performed with a cane but without orthosis. Levels are defined as:

Level 0, the patient cannot walk at all or requires the help of two or more people; Level I, the patient needs continuous support from one person who helps to carry the patient's weight and helps with balance; Level II, the patient is dependent on the continuous or intermittent support of one person to help with balance and coordination; Level III, the patient needs only verbal supervision; Level IV, help is required for stairs and uneven surfaces; and Level V, the patient can walk independently anywhere.

### WS

WS was measured in meters per second as the patient walked across a 10-m walkway. [35] Patients were allowed to use the walking aids they required, and necessary assistance to compensate for the loss of balance was provided.

### BBS

It evaluates 14 sitting and standing activities, each on a graded 5-point scale (0-4). [36] The maximum score is 56. Higher scores indicate better balance: 0-20, wheelchair bound; 21-40, walking with assistance; and 41-56, independent. It can be sub-divided into nine balance and five motor activities. It has been tested on patients with stroke and has a good inter-rater and intra-rater reliability of 0.98 and 0.99, respectively. [37]

### SSS

Impairment after stroke was assessed on the SSS. It consists of eight parameters, including consciousness, cognitive deficits, motor power and walking ability on a graded score of 0-12. The maximum score is 58, and higher scores indicate better outcome. [38]

### BI

The functional level of independence was assessed with the BI, which can be sub-divided to measure discrete functions of self-care and mobility with an overall score of 100. [39] This index has been widely used for stroke patients and has high reliability and validity and moderate responsiveness to changes in the functional ability over time.

## » Results

Two hundred and forty-five stroke patients were screened during the study period, of whom 65 patients fulfilled the inclusion criteria. Of these patients, 40 patients gave informed consent and were included in the study [Figure 1]. The clinic-demographic profile of these patients is given in [Table 1].

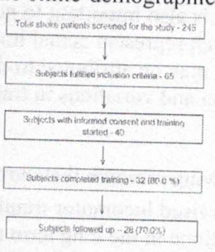


Figure 1: Flow chart of the study

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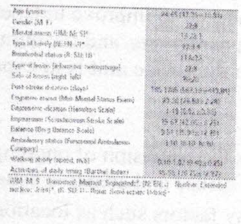

Table 1: Demographic and clinical profile of the patient population ($n$=40)

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The pre-training and post-training scores were compared among patients (n = 32) who completed the training as per protocol. The analysis revealed statistically significant differences at the end of training for all primary and secondary outcome measures [Table 2]. It is important to note that at the end of training, all patients were able to walk without support of any other person (FAC grade III-V) as compared with eight patients at the beginning of the training who required support to walk (FAC grade II).

Table 2: Improvement in mean walking speed (m/s), Functional Ambulation Category, Berg Balance Scale, Scandinavian Stroke Scale and Barthel Index at the completion of training (D/20) and follow-up (F/U) compared with baseline (D/0)

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Four patients (10.0%) dropped out during the follow-up phase, leading to a total dropout rate of 12 (30.0%) at the end of the study. Patients completing the training as per protocol were evaluated at 3 months of follow-up. When patients who completed the study were compared with those who dropped out during the training or follow-up phase, it was noted that patients who dropped out were older with more post-stroke duration but with a comparable level of disability ($P > 0.05$).

**Follow-up results**

Twenty-eight patients (70.0%) reported for the follow-up evaluation. The patients were re-evaluated on all outcome measures. The analysis revealed statistically significant differences for all primary and secondary outcome measures at follow-up as compared with the pre-training scores [Table 2]. It is important to note that all patients were able to maintain the improvement to a statistically significant level even at 3 months of follow-up.

## » Discussion

The results of this prospective repeated-measure study indicate that chronic stroke survivors with impaired balance and gait who received 4 weeks of locomotor training showed better walking, balance and functional abilities both at the end of training and at 3 months of follow-up. This implies that the improvements achieved during training can be maintained, resulting in better functional abilities and improved performance of ADL.

According to the specificity of learning hypothesis, [41] the best motor learning occurs if performance during practice is well matched to the performance required for retention and transfer conditions. Motor learning reflects a neural specificity of practice because motor learning involves the integration of motor and sensory information that is available during practice. [42] The specificity of the learning hypothesis is consistent with recent advances in neurorecovery and neuroplasticity, which have shown that task-specific activity results in changes in the nervous system that correlate with improvements in motor behavior. Recently, a human study [43] has shown that neurorecovery and functional performance are enhanced when training incorporates motor tasks of greater complexity and may induce changes in corticomotor excitability. The enhanced performance among the chronic stroke survivors in our study suggests that the greatest gains in locomotion after stroke may be associated with training interventions that are task specific and have high intensity demands.

The patients recruited in this study had moderate functional disabilities as profiled by the clinical measures of walking and functional ability. In general, they presented with attributes typical of chronic stroke patients undergoing a late-phase rehabilitation program, especially to improve their walking ability to achieve maximal functional independence. In stroke rehabilitation, the use of task-specific training is increasingly mentioned, [12],[13],[14],[15],[16],[17],[18],[19],[20],[21],[22],[23],[24] although it has yet to be widely used in the chronic phase. A relevant finding from this study is that majority (80.0%) of these patients were able to complete the 4-week training protocol. This suggests that task-specific locomotor training is well tolerated by chronic stroke survivors.

The present study differs from earlier studies with respect to the outcome measures studied. [44],[45] This study evaluated the effect of task-specific locomotor training not only on walking ability but also on balance, overall disability and independence in performing the ADL. It is also important to note that the effect of training was evaluated only on over ground outcome measures, which represent actual improvement for the patients. The high degree of variability in outcome from previous studies may be attributed to differences in time since stroke, locomotor impairment severity, duration of intervention and variations in training protocols across the studies. [45],[46]

The positive results of this study contribute to the growing research that chronic stroke survivors are able to improve the performance of everyday tasks with supervised locomotor training. [7],[8],[9] This suggests that to maximize potential, stroke rehabilitation needs to continue in the long term rather than cease within few months to 1 year post stroke. Accessible ongoing programs focused to improve independency in ADL will not only improve quality of life but also reduce dependency on caregivers, and the duration and need for institutional care. One way to monitor performance after discharge from the stroke unit is to expand routine medical follow-up by including assessment of physical function. [44]

One of the major challenges of stroke rehabilitation is the provision of ongoing programs that maintain and/or improve performance rather than allowing secondary disuse and adaptive behaviors to increase the disability after primary discharge from the stroke unit. [44] Many factors such as location, cost, intensity, frequency and duration of such programs warrant further investigations. The high compliance indicates that chronic stroke survivors will participate in these programs if financial and transportation requirements are met. [14]

The major limitation of this study was the absence of a control group. However, the primary purpose of this study was to demonstrate the efficacy of a particular type of intervention and to determine its feasibility in chronic stroke survivors. A randomized, controlled trial with a large number of participants is needed to verify the benefits of this intervention for people with this type of stroke population. A study that includes measures of quality of life, community participation and handicap will give better insight of the relationship between impairment levels, functional changes and handicap. Another limitation of the study is that it involves stroke survivors with moderate disability, but that is typical of any chronic stroke rehabilitation program that consists primarily of those who are able to walk with or without support but want to further improve their locomotor skills to achieve maximum independency in ADL. No comparison was made between the data at the end of the training and at 3-month follow-up. That would have provided better insight about retention of rehabilitation intervention benefits over a period of time.

## » Conclusion

This study demonstrated that it is feasible to conduct locomotor training programs for chronic stroke survivors with moderate disabilities. The stroke population that participated in this task-specific training program gained and maintained improvements in walking and functional abilities. Improvements in ambulation provide the chronic stroke survivor with the opportunities to participate in the community and reduced burden on caregivers. Future research should focus on the development and provision of efficient and effective long-term rehabilitation programs that optimize performance and reduce disability and handicap after stroke.

## » References


1. Hill K, Ellis P, Bernhardt J, Maggs P, Hull S. Balance and mobility outcomes for stroke patients: A comprehensive audit. Aust J Physiother 1997;43:173-80.
2. Harwood RH, Gompertz P, Pound P, Ebrahim S. Determinants of handicap 1 and 3 years after a stroke. Disabil Rehabil 1997;5:205-11.
3. Corr S, Bayer A. Poor functional status of stroke patients after hospital discharge: Scope for intervention? Br J Occup Ther 1992;55:383-5.
4. Wade DT, Wood VA, Hewer RL. Recovery after stroke: The first 3 months. J Neurol Neurosurg Psychiatry 1985;48:7-13.
5. Kelly-Hayes M, Wolf PA, Kase CS, Gresham GE, Kannel WB, D' Aostino RB. Time course of functional recovery after stroke: The Framingham study. J Neurol Rehabil 1989;3:65-70.
6. Tangeman P, Banaitis D, Williams A. Rehabilitation for chronic stroke patients: Changes in functional performance. Arch Phys Med Rehabil 1990;71:876-80.
7. Werner R, Kessler S. Effectiveness of an intensive outpatient rehabilitation program for post acute stroke patients. Am J Phys Med Rehabil 1996;74:114-20.
8. Rodriguez AA, Black PO, Kile KA, Sherman J, Stellberg B, McCormick J, *et al*. Gait training efficacy using a home-based practice model in chronic hemiplegia. Arch Phys Med Rehabil 1996;77:801-5.
9. Dean CM, Shepherd RB. Task related training improves the performance of seated reaching tasks after stroke. A randomized controlled trial. Stroke 1997;28:722-8.
10. Green J, Forster A, Bogle S, Young J. Physiotherapy for patients with mobility problems more than 1 year after stroke: A randomized controlled trial. Lancet 2002;359:100-3.
11. Wade DT, Collen FM, Robb GF, Warlow CP. Physiotherapy intervention late after stroke and mobility. BMJ 1992;304:609-13.
12. Kosak MC, Reding MJ. Comparison of partial body weight supported treadmill gait training versus aggressive bracing assisted walking post stroke. Neurorehabil Neural Repair 2000;14:13-9.
13. Nillson L, Carlsson J, Danielsson A, Fugl-Meyer A, Hellström K, Kristensen L, *et al*. 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. Clin Rehabil 2001;15:515-27.
14. Ada L, Dean CM, Hall JM, Bampton J, Crompton S. A treadmill and over ground walking program improves walking in persons residing in the community after stroke: A placebo-controlled, randomized trial. Arch Phys Med Rehabil 2003;84:1486-91.
15. da Cunha IT, Lim PA, Qureshy H, Henson H, Monga T, Protas EJ. Gait outcomes after acute stroke rehabilitation with supported treadmill ambulation training: A randomized controlled pilot study. Arch Phys Med Rehabil 2002;83:1258-65.

16. Hesse S, Bertelt C, Jahnke MT, Schaffrin A, Baake P, Malezic M, *et al*. Treadmill training with partial body weight support compared with physiotherapy in nonambulatory hemiparetic patients. Arch Phys Med Rehabil 1995;26:976-81.

17. Hesse S, Konrad M, Uhlenbrock D. Treadmill walking with partial body weight support versus floor walking in hemiparetic subjects. Arch Phys Med Rehabil 1999;80:421-7.

18. Pohl M, Mehrholz J, Ritschel C, Rückriem S. Speed-dependent treadmill training in ambulatory hemiparetic stroke patients: A randomized controlled trial. Stroke 2002;33:553-8.

19. Sullivan KJ, Knowlton BJ, Dobkin BH. Step training with body weight support: Effect of treadmill speed and practice paradigms on post stroke locomotor recovery. Arch Phys Med Rehabil 2002;83:683-91.

20. Trueblood PR. Partial body weight treadmill training in persons with chronic stroke. Neurorehabilitation 2001;16:141-53.

21. Visintin M, Barbeau H, Korner-Bitensky N, Mayo NE. A new approach to retrain gait in stroke patients through body weight support and treadmill stimulation. Stroke 1998;29:1122-8.

22. Werner C. Bardeleben A, Mauritz KH, Kirker S, Hesse S. Treadmill training with partial body weight support and physiotherapy in stroke patients: A preliminary comparison. Eur J Neurol 2002;9:639-44.

23. Sullivan KJ, Brown DA, Klassen T, Mulroy S, Ge T, Azen SP, *et al*. Effects of task-specific locomotor and strength training in adults who were ambulatory after stroke: Results of the STEPS randomized clinical trial. Phys Ther 2007;87:1580-602.

24. Wevers L, De Port IV, Vermue M, Mead G, Kwakkel G. Effects of task-oriented circuit class training on walking competency after stroke. A systematic review. Stroke 2009;40:2450-9.

25. Tang A, Eng J, Rand D. Relationship between perceived and measured changes in walking after stroke. J Neurol Phys Ther 2012;36:115-21.

26. Reisman DS, MacLeod SB, Farquhar WB. Changes in metabolic cost of transport following locomotor training post-stroke. Top Stroke Rehabil 2013;20:161-70.

27. Mudge S, Barber PA, Stott NS. Circuit-based rehabilitation improves gait endurance but not usual walking activity in chronic stroke: A randomized controlled trial. Arch Phys Med Rehabil 2009;90:1989-96.

28. Mansfield A, Wong JS, Bayley M, Lou Biasin L, Brooks D, Brunton K, *et al*. Using wireless technology in clinical practice: Does feedback of daily walking activity improve walking outcomes of individuals receiving rehabilitation post-stroke? Study protocol for a randomized controlled trial. BMC Neurol 2013;13:93.

29. States RA, Pappas E, Salem Y. Overground physical therapy gait training for chronic stroke patients with mobility deficits. Cochrane Database Syst Rev 2009;3:CD006075.

30. Westlake KP, Patten C. Pilot stuy of lokomat versus manual-assisted treadmill training for locomotor recovery post-stroke. J Neuroengineering Rehabil 2009;6:18.

31. Moraru E, Onose G. Current issues and considerations about the central role of rehabilitation therapies in the functional recovery of neurological impairments after stroke in adults. J Med Life 2014;7:368-72.

32. Moore JL, Roth EJ, Killian C, Hornby TG. Locomotor training improves daily stepping activity and gait efficiency in individuals poststroke who have reached a "plateau" in recovery. Stroke 2010;41:129-35.

33. Kelvin WK, Margaret KY. Speed-dependent treadmill training is effective to improve gait and balance performance in patients with sub-acute stroke. J Rehabil Med 2011;43:709-13.

34. Jayaram G, Stagg CJ, Esser P, Kischka U, Stinear J, Berg HJ. Relationships between functional and structural corticospinal tract integrity and walking post stroke. Clin Neurophysiol 2012;123:2422-8.

35. Perry J, Garrett M, Gronley JK, Mulroy SJ. Classification of walking handicap in the stroke population. Stroke 1995;26:982-9.

36. Wade DT, editor. Measurement in neurological rehabilitation. Oxford, UK: Oxford University Press; 1992.

37. Berg K, Maki BE, Williams JI, Holiday J, Wood-Dauphinee S. Clinical and laboratory measures of postural balance in elderly population. Arch Phys Med Rehabil 1992;73:1073-80.

38. Berg K, Wood-Dauphinee S, William JT, Gayton D. Measuring balance in the elderly: Preliminary development of an instrument. Physiother Can 1989;41:304-11.

39. Scandinavian Stroke Study Group. Multi-center trial of hemodilution in ischemic Stroke-background and study protocol. Stroke 1985;16:885-90.

40. Mahoney FI, Barthel DW. Functional evaluation: The Barthel Index. Md State Med J 1965;14:56-61.

41. Granger CV, Dewis LS, Peters NC, Sherwood CC, Barrett JE. Stroke rehabilitation analysis of repeated Barthel Index measures. Arch Phys Med Rehabil 1979;60:14-7.

42. Nudo RJ, Milliken GW, Jenkins WM, Merzenich MM. Use dependent alterations of movement representations in primary motor cortex of adult squirrel monkeys. J Neurosci 1996;16:785-807.

43. Schmidt RA, Lee TD. Motor control and learning: A behavioral emphasis. 3 rd ed. Champaign (IL): Human Kinetics; 1998.

44. Yen CL, Wang RY, Liao KK, Huang CC, Yang YR. Gait training induced change in corticomotor excitability in patients with chronic stroke. Neurorehabil Neural Repair 2008;22:22-30.

45. Dean CM, Richards CL, Malouin F. Task related circuit training improves performance of locomotor tasks in chronic stroke: Randomized controlled trial. Arch Phys Med Rehabil 2000;81:409-17.

46. Plummer P, Behrman AL, Duncan PW. Effects of stroke severity and training duration on locomotor recovery after stroke. Neurorehabil Neural Repair 2007;21:137-51.

Figures

[Figure 1]

Tables

[Table 1], [Table 2]



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