Six-month functional recovery of stroke patients: a multi-time-point study

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The aim of this study is to compare the time-course changes in neurologic impairments (trunk control, motor function, sensory, and cognition) and recovery in functional impairments (activity of daily livings and gait) simultaneously from initiating rehabilitation to 6 months after stroke. Consecutive stroke patients were recruited from the department of nervous surgery, and transferred into the department of rehabilitation medicine and continued on treatment during the acute stage. Outcome measures were examined at the initial rehabilitation baseline, 1, 2, and 4 weeks after rehabilitation treatment, and 3, 4, 5, and 6 months after stroke. Patients were assessed using the Trunk Impairment Scale, the Fugl-Meyer Motor and Sensory Assessments for the upper and lower limbs, Mini-Mental State Examination, Functional Ambulation Category, and Modified Barthel Index. Twenty consecutive patients were analyzed in the study with complete assessments. The recovery was relatively rapid during the 4 weeks after treatment (*P* value ranges from <0.001 to <0.007) and then to a lesser extent decelerated between 3 and 6 months after stroke (*P* value between <0.001 and 0.080). Statistical comparison by repeated measures analysis showed a significant interaction between time points and measures of all recovery variables ($P<0.001$). Significant differences in level of impairments and functional recovery were found at the different time points. In comparison with the lower leg and trunk control, the upper arm showed less recovery, with a significant difference. All variables except for leg motor function improved continuously over 6 months after stroke. Nevertheless, this study confirms the importance of the period within 3 months for recovery after stroke, during which most of the recovery occurred, ranging from 48 to 91%. Therefore, intensive treatment targeting motor and sensory functions early after stroke may be beneficial for recovery of impairments and functional performance. ***International Journal of Rehabilitation Research*** **38:173–180 Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.**

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Introduction

The evaluation of recovery following a stroke is critical for the purposes of both treatment and research. Despite severe disabilities and neurological impairments during the early poststroke period, most stroke patients achieve some degree of recovery over time (Wade and Hewer, 1987; Duncan *et al.*, 1992). For example, some stroke patients show early motor function recovery, which primarily occurs within the first few months (Hendricks *et al.*, 2002). Although the degree of paralysis is a primary predictor, it cannot be used to accurately predict the rate of motor recovery during the subacute stage with reference to the patient's initial condition (Hendricks *et al.*, 2002). Improvement in lower motor function is observed in ~65% of patients with initial motor deficits (Hendricks *et al.*, 2002); however, the probability of normal recovery in the upper limbs is very low (<15%) (Cauraugh and Summers, 2005). In addition, the rate of clinical recovery is relatively rapid during the first few weeks after a stroke, but then slows considerably between 1 and 3 months later. Between 3 and 6 months after stroke, recovery has slowed so much as to be barely noticeable, although there appears to be an overall trend toward some additional recovery during this time (Duncan and Lai, 1997). This small additional improvement generally occurs within 6 months after stroke and involves gait and motor function (Friedman, 1990; Jorgensen *et al.*, 1995).

Recovery following a stroke is typically classified into neurological recovery and functional recovery; neurological recovery varies according to stroke pathogenesis and lesion site, whereas functional recovery is influenced by the external environment, continuity of rehabilitation, and motivation (Anderson *et al.*, 1974). Although the change in recovery varies after stroke, the recovery procedure does not make a remarkable difference (Nudo, 2003). For this reason, the analysis of recovery profiles is important because this information can provide a more specific plan for stroke rehabilitation (Jang, 2007). To maximize its effectiveness, physical therapy (PT) should be evidence-based and should focus on specific stroke components or impairments for intervention. The analysis of recovery profiles has raised the possibility that specific therapeutic windows exist during which a given therapy will be most effective (Duncan *et al.*, 1992; Hendricks *et al.*, 2002; Nudo, 2003; Verheyden *et al.*, 2008). However, our knowledge of the details of stroke recovery remains limited and there are few validated predictors of clinical recovery and generally insufficient data on the degree of recovery that can be achieved. More detailed research into stroke recovery is therefore necessary to establish effective treatment plans (Duncan *et al.*, 1992), and an accurate analysis and comprehensive evaluation of the various aspects of stroke recovery are critical in treating patients with multiple problems (Hendricks *et al.*, 2002). Moreover, studies examining the differential pattern of recovery with respect to trunk control, motor function of the arms and legs, cognition, functional ability and gait dependency over time might aid in the planning and timely introduction of rehabilitation strategies. The aims of this study were to simultaneously compare changes in trunk control, motor function, gait, sensory, cognitive, and functional abilities during post-treatment through to 6-month poststroke recovery.

Methods

Participants and procedure

A prospective longitudinal 6-month follow-up study was carried out over the course of 20 months from August 2011 to April 2013.

Early-stage patients who had suffered from single-onset stroke were recruited from the Department of Neurosurgery, transferred to the Department of Rehabilitation Medicine, and continued on treatment during the acute stage. Stroke was defined as the acute onset of neurological deficit lasting more than 24 h or leading to death, with no apparent cause other than cerebro-vascular disease. Patients were included in the study if they were 20–90 years old, had received a diagnosis of stroke by computed tomography or MRI, and had no hip prosthesis on the less affected side or any other orthopedic or neurological impairment that could influence poststroke recovery. Patients with a motor deficit (arm or leg) lasting longer than 2 weeks were included if they scored less than 60 out of 66 points for the upper extremity or less than 28 out of 34 points for the lower extremity on the Fugl-Meyer Assessment of Sensorimotor Recovery after Stroke. In addition, only patients who could not walk within 2 weeks after onset were recruited, provided that they could follow simple instructions from a therapist (i.e. raise your arm or pull/push your leg). Patients with indications of a subarachnoid hemorrhage, transient ischaemic attack, brainstem lesion, or severe communication or memory deficit were excluded. This study was carried out on patients admitted to St Vincent's Hospital of the Catholic University of Korea. Our study followed the principles of the Declaration of Helsinki and all patients provided informed consent. All patients began treatment if they were in stable condition, and were examined at initial rehabilitation (baseline), at 1, 2, and 4 weeks after rehabilitation in our rehabilitation hospital and at 3, 4, 5, and 6 months after stroke in other rehabilitation hospitals because they were transferred to other hospitals because of the hospitalization period. Tests during from 3 to 6 months after stroke were performed at a nearby rehabilitation center, whereas patients were evaluated in our hospital if they were readmitted for primary care visits. The participants received therapies on the basis of a neurodevelopmental treatment approach for 1 h a day for 6 days a week, including each of PT and occupational therapy (OT), as acute inpatients, followed by 2 h (PT) and 1 h (OT) a day per week during subacute phases (3–6 m). They also received speech therapy (ST), as needed. The interventions were mainly focused on using an affected limb, mat activity, symmetric weight bearing and transfer, and gait training for the swing and stance symmetry, but not operated exclusively for a particular purpose.

Assessment

All patients were screened by one physiotherapist (K.B.) to obtain a patient's information through admission notes at the start of rehabilitation, and then they were evaluated in several assessments. Clinical assessments to document changes in motor and sensory function, cognition, walking, and functional recovery after stroke included the Trunk Impairment Scale (TIS), the Fugl-Meyer Assessment of Sensorimotor Function after Stroke, the Mini-Mental State Examination (MMSE), Functional Ambulation Category (FAC), and the Modified Barthel Index (MBI).

Trunk balance was assessed using TIS, which indicates motor impairment of the trunk following stroke. It assesses static and dynamic sitting balance and trunk coordination, with a score ranging from 0 to 23 points (Verheyden *et al.*, 2004). A higher score indicates better trunk control. The reliability and validity of this test for stroke patients have been documented in previous studies (Verheyden *et al.*, 2004).

Motor function was assessed using the Fugl-Meyer Assessment of Sensorimotor Function after Stroke, which consists of two subscales to evaluate motor function in the upper and lower extremities (Fugl-Meyer *et al.*, 1975). The scoring range was 0–66 points and 0–34 points for the upper and the lower extremities, respectively. In this study, the score reported does not include the coordination subscore (i.e. the highest scores achievable were 60 and 28 for the upper and the lower extremities, respectively). Adequate psychometric properties for the FMA have been presented (Platz *et al.*, 2005).

Sensory function was evaluated using the Fugl-Meyer Assessment of Sensorimotor Function after Stroke, which consists of light touch and position sense measurements (Fugl-Meyer *et al.*, 1975). A cotton swab was used to apply light touches to the upper limbs on the forearm and palm, as well as to the lower leg and the sole of the foot for the lower limbs. Proprioception (while blinded) was tested on the shoulder, elbow, wrist, and thumb for the upper extremities, and on the hip, knee, ankle, and big toe for the lower extremities. The highest score achievable was 24 points.

We used the MMSE (Folstein *et al.*, 1975), one of the most widely used cognitive assessments, to investigate the recovery of cognition. This test consists of 12 questions and six items that assess the following: orientation to time and place, memory registration, memory recall, attention/calculation, language, and comprehension/judgment. The total score achievable is 30 points, where a higher score indicates superior cognitive function.

The FAC was designed to provide information on the level of physical support needed by the patient to ambulate both outdoors and indoors (Holden *et al.*, 1986). This assessment included six categories ranging from 0 (requiring continuous support from two individuals) to 5 (ability to walk indoors and outdoors independently). Adequate psychometric properties for the FMA have been presented (Mehrholz *et al.*, 2007)

The MBI developed by Shah *et al.* (1989) is a measure of functional ability after stroke. We used the 10-item version, which has a maximum score of 100. A high score indicates that the patient is completely independent for several activities of daily living (ADLs). Adequate psychometric properties for the FMA have been presented (Hsueh *et al.*, 2002). To increase the reliability of our test results, a single assessor carried out the same assessments in all patients: one assessor (an occupational therapist) evaluated cognitive ability and functionality in terms of ADLs, whereas a second assessor (a physical therapist) evaluated sensorimotor function, trunk balance, and gait stability. Because this study focused on how stroke patients with paralysis and ambulation difficulty will recover after a spontaneous change, to minimize the effects of motor recovery because of reversal of diaschisis or recovery of neural function in the ischemic penumbra, we studied changes in patients with plegic limbs persisting for an average of 2 weeks after stroke.

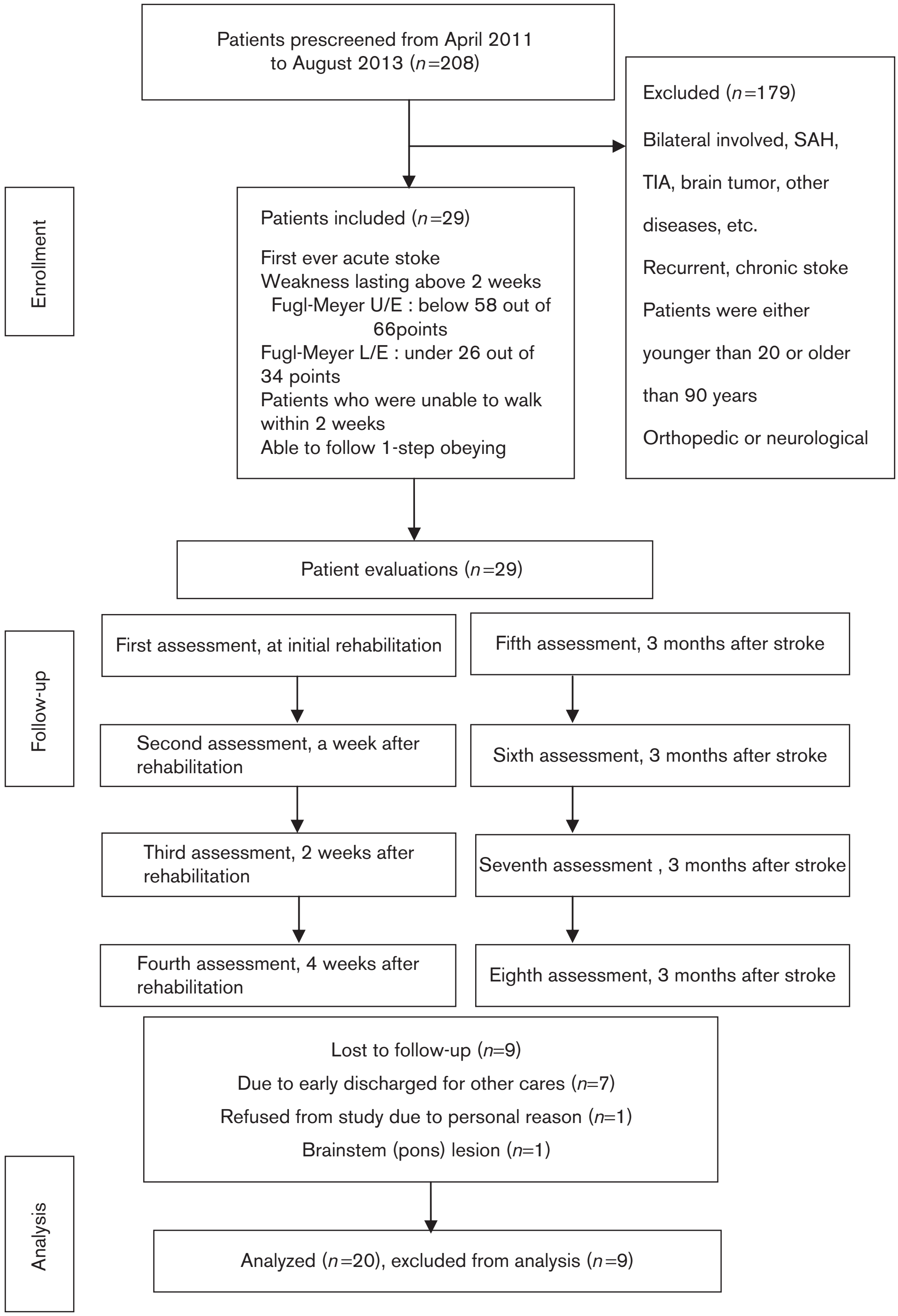
Statistical analysis

Data of complete assessments were analyzed using SPSS software version 12.0 (SPSS Inc., Chicago, Illinois, USA). Dropout data were not included for analysis. A normality test was performed. Among the parameters examined, the data for trunk balance, motor function of the lower extremities, sensory function, functional ADLs, and cognition showed normal distributions. Parametric and nonparametric statistics were used to describe recovery after stroke. Changes in recovery scores during over 6 months after stroke were evaluated separately using one-way analysis of variance for repeated measures or the Friedman test depending on whether the data were normal or non-normally distributed, respectively. If the effect identified using the Friedman test was significant ($P < 0.05$), a pair-wise comparison was performed using the Wilcoxon signed-rank test to identify at which two measurement points a significant difference occurred. In the final analysis, data scores were transformed into percentages of the maximum score of each scale, and an analysis of two-way repeated measures was carried out to investigate the relative change in recovery variables (variables × time). Post-hoc analysis with the Bonferroni method was used, for which the level of significance was set at P less than 0.05; for post-hoc analysis of nonparametric statistics, Bonferroni correction for multiple comparisons was set at P less than 0.0083 (0.05/6). If an interaction effect of variables in two-way repeated measures was found, the adjusted P value for multiple comparisons at the each time periods was P less than 0.0018 (0.05/28). On the basis of the pilot samples during study, we calculated a minimal sample size of 14 participants in this study, given a power of more than 80% to detect an interaction in the two-way repeated measures, an effect size of 0.61, seven variables, and four repeated measurements using a program of G*Power (version 3.1; Heinrich-Heine-Universität, Düsseldorf, Germany).

Results

Twenty out of 29 consecutive patients fulfilling the above criteria finished all assessments in the study and were included for analysis. Of these participants, nine dropped out, seven were discharged early, one refused to participate because of personal reasons, and one had a brainstem lesion. Nine of these 29 patients were excluded from the study because they could not complete assessments over 6 months after stroke. Figure 1 shows the flow diagram of study. Participant characteristics are presented in Table 1. The mean age of the patients was 53.3 ±15.2 years. The period from stroke onset to starting PT/OT was a mean of 15.6 ± 6.3 days. All patients had a cortical or a subcortical lesion and were dominant in the right hand. Twelve patients showed evidence of hemorrhage and eight

Fig. 1



Flow diagram of patients recruited into this study.

patients showed evidence of infarction. Seven patients showed evidence of one-sided visual neglect.

Clinical recovery data for the trunk, arm, leg, sensory function, cognition, gait, and functional performance are presented in Table 2. The results show significant recovery over time for all variables. All variables showed continuous improvement over 6 months after stroke, with the exception of leg motor function, which showed little improvement during the period from 3 to 6 months after

Table 1 Demographic data of the participants

Demographics ($n = 20$)	
Sex, male/female (%)	50/50
Age (mean ± SD) (years)	53.3 ± 15.2
Handedness, R/L (%)	100/0
Side of stroke, R/L (%)	45/55
Time from stroke to rehabilitation (days) (mean ± SD)	15.7 ± 6.1
Stroke pathology, hemorrhage/infarction (%)	60/40
Neglect (%)	35
Brain injury location/cause of lesion [*n* (%)]	
ICH BG	8 (40)
ICH thalamus	2 (10)
ICH T-P	1 (5)
ICH F-T	1 (5)
Infarction MCA	6 (30)
Infarction BG	1 (5)
Infarction, internal capsule and PVWM	1 (5)

BG, basal ganglia; F-T, frontotemporal; ICH, intracerebral hemorrhage; MCA, middle cerebral artery stroke; PVWM, periventricular white matter; R/L, right/left; T-P, temporoparietal.
[a]Mean ± SD.

stroke. However, for gait and functional performance, a large degree of change was apparent continuously from 3 to 6 months after stroke, but the recovery between weeks was not significantly apparent.

Repeated-measures analysis showed a significant interaction between time points and recovery variables ($P < 0.001$, Table 3), indicating a statistical difference in recovery for the different measures. Table 4 presents an overview of the mean for all recovery variables expressed as a percentage of the maximum score. The results of the repeated-measures analysis showed that there were significant differences between the measures of variables at pretreatment, 4 weeks after treatment, and 3 and 6 months after stroke (Table 4). At the initial assessments, cognitive function scored higher compared with all other variables, except for leg motor function, and there was a significant difference between lower motor function and gait ability. At 4 weeks after treatment, upper motor function, sensory, and gait had a comparatively higher score than cognition. Upper motor function showed relatively lower scores compared with lower motor function and gait ability at 3 months after stroke. At 6 months after stroke, upper motor function scored lower compared with trunk balance, lower motor function, ADL, gait ability, and cognition.

In Fig. 2, at 1 month after treatment, trunk control showed a marked improvement from 28 to 70%, and upper and lower motor function also showed improvements from 21 to 39% and from 39 to 68%, respectively. Sensory function improved from 30 to 53%. In terms of functional activity, the ADL parameter showed an improvement from 26 to 58% and gait showed an improvement from 7 to 45%. Although a relatively large change in recovery was apparent for almost all variables over 4 weeks after rehabilitation, small changes were observed during from 3 to 6 months after stroke for

Table 2 Repeated results of clinical recovery

		From initial rehabilitation to 4 weeks after treatment								From 3-6 months after stroke						
Measure (score)	Time effect *P* value	Pretreatment	Week 1	Post hoc (pre–week 1)	Week 2	Post hoc (weeks 1–2)	Week 4	Post hoc (weeks 2–4)	Time effect *P* value	Month 3	Month 4	Post hoc (months 3–4)	Month 5	Post hoc (months 4–5)	Month 6	Post hoc (months 5–6)
TIS (0–23)	< 0.001	6.55 ± 5.91	11.30 ± 5.96	< 0.05	14.60 ± 4.24	< 0.05	16.15 ± 4.22	< 0.05	0.011	18.39 ± 3.47	19.00 ± 3.29	NS	19.33 ± 3.09	NS	19.56 ± 3.03	NS
F–M arm (0–60)	< 0.001	12.20 ± 14.94	15.50 ± 16.71	< 0.0083	18.70 ± 17.13	< 0.0083	22.55 ± 17.38	< 0.0083	< 0.001	27.80 ± 19.82	29.50 ± 19.55	NS	30.55 ± 20.14	NS	31.20 ± 20.23	NS
F–M leg (0–28)	< 0.001	10.05 ± 6.80	13.20 ± 7.01	< 0.05	16.50 ± 7.33	< 0.05	17.75 ± 6.52	< 0.05	0.080	20.35 ± 4.80	20.50 ± 4.77	NS	21.25 ± 4.23	NS	21.50 ± 4.42	NS
F–M sensory (0–24)	0.007	7.30 ± 8.24	7.85 ± 8.24	NS	10.05 ± 8.59	< 0.05	12.60 ± 8.82	NS	0.038	14.95 ± 8.35	15.75 ± 8.38	NS	16.60 ± 8.55	NS	15.40 ± 9.32	NS
MMSE (0–30)	< 0.001	18.95 ± 7.38	22.00 ± 6.43	< 0.05	23.55 ± 5.87	< 0.05	26.45 ± 3.14	< 0.05	0.044	27.45 ± 2.98	28.20 ± 2.19	NS	28.40 ± 1.96	NS	28.80 ± 1.79	NS
FAC (0–5)	< 0.001	0.40 ± 0.82	1.00 ± 1.26	< 0.0083	1.60 ± 1.27	< 0.0083	2.25 ± 1.62	< 0.0083	< 0.001	3.55 ± 1.23	3.85 ± 1.31	NS	4.20 ± 1.01	NS	4.25 ± 0.91	NS
MBI (0–100)	< 0.001	25.50 ± 17.56	38.75 ± 17.60	< 0.05	50.50 ± 17.16	< 0.05	58.15 ± 17.41	< 0.05	0.002	77.15 ± 17.67	82.50 ± 16.43	< 0.05	87.95 ± 11.60	< 0.05	90.50 ± 10.02	< 0.05

FAC, Functional Ambulation Category; F-M arm, Fugl–Meyer arm section; F-M leg, Fugl–Meyer leg section; F-M sensory, Fugl–Meyer sensory section; MBI, Modified Barthel Index; MMSE, Mini-Mental State Examination; TIS, Trunk Impairment Scale.

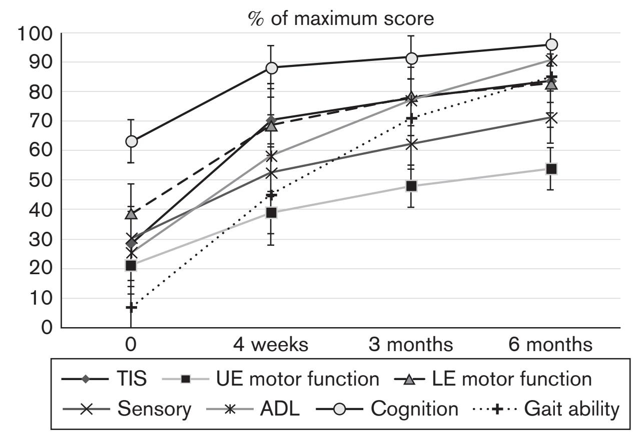
Table 3 Results of two-way repeated-measures analysis of variance

Variables	d.f.	*F*	*P*-value
Recovery variables	6	8.374	0.000***
Time	3	233.376	0.000***
Recovery variables × time	18	5.283	0.000***

*$P<0.05$.
**$P<0.01$.
***$P<0.001$.

parameters related to neurologic impairments, including control of the trunk (6%), arm (6%), leg (4%), sensory (9%), and cognition (5%). However, functional recovery, as indicated by ADL and gait ability, showed slightly greatly increases of 13 and 14%, respectively. ADL and gait scores improved quickly and continuously over 6 months after stroke, whereas trunk, arm, leg, sensory, and cognition showed larger changes at 3 months after stroke. Since this period, neurologic impairments showed relatively small changes compared with functional activities.

Fig. 2



Comparison of recovery rates following stroke. LE, lower extremity; TIS, Trunk Impairment Scale; UE, upper extremity.

Discussion

The overall objective of this study was to simultaneously compare time-dependent changes in trunk control, motor function, sensory function, cognition, and functional ability, including ADL and gait impairment. In a previous review by Kwakkel *et al.* (2004), most functional recovery occurred within 6 months after stroke; however, the authors noted a nonlinear relationship between motor impairment and functional recovery. Our results are consistent with previous studies. The greatest degree of recovery occurred relatively rapidly during the first 4 weeks after treatment (i.e. neurologic impairments); recovery was also observed during from 3 to 6 months after stroke, but to a lesser extent. This is important because most previous studies report little to no observable recovery between 3 and 6 months after stroke (Duncan and Lai, 1997; Verheyden *et al.*, 2008). In contrast, our results show a small but significant improvement for all recovery variables during from 3 to 6 months after stroke, with the exception of lower motor function, indicating that recovery had not yet plateaued. Lower motor function plateaued earlier than upper limb function, but also showed higher motor function than the upper limb. Our results are consistent with a previous review by Hendricks *et al.* (2002), which reported that the rate of recovery of the lower limb was faster than that of the upper limb, and that the more severe the impairment, the longer the period of recovery. One possible explanation for this result could be the severity of patients with initial motor and functional deficits ranging from 7 to 30%. Cognition and lower motor function were 63 and 39% higher at the initial assessment, respectively, and this could give rise to an earlier plateau phase.

The recovery of sensory function was less prominent in our study, which was potentially because of the rapid recovery of motor function following stroke (Duncan *et al.*, 1994; Jorgensen *et al.*, 1995; Verheyden *et al.*, 2008).

Table 4 Multiple comparisons of recovery in all variables (% estimates ± SE of maximum score)

	Before treatment		4 weeks after treatment		3 months after stroke		6 months after stroke	
Variables	Estimates ± SE	95% CI	Estimates ± SE	95% CI	Estimates ± SE	95% CI	Estimates ± SE	95% CI
Trunk control (0–23)	28.48 ± 5.53[g]	17.54–39.42	70.22 ± 5.78	58.79–81.64	77.39 ± 5.35	66.80–87.98	83.48 ± 4.83[b]	73.92–93.04
UE motor (0–60)	21.03 ± 5.53[g]	10.09–31.98	38.88 ± 5.78[g]	27.45–50.31	47.93 ± 5.35[c,g]	37.34–58.52	53.79 ± 4.83[a,c,e,f,g]	44.24–63.35
LE motor (0–28)	38.65 ± 5.53[f]	27.71–49.60	68.27 ± 5.78	56.84–79.70	78.27 ± 5.35[b]	67.68–88.86	82.69 ± 4.83[b]	73.14–92.25
Sensory (0–24)	30.42 ± 5.53[g]	19.48–41.36	52.50 ± 5.78[g]	41.07–63.93	62.29 ± 5.35	51.70–72.88	71.25 ± 4.83	61.69–80.81
ADL (0–100)	25.50 ± 5.53[g]	14.56–36.44	58.15 ± 5.78	46.72–69.58	77.15 ± 5.35	66.56–87.74	90.50 ± 4.83[b]	80.94–100
Gait (0–5)	7.00 ± 5.53[c]	0–17.94	45.00 ± 5.78[g]	33.57–56.43	71.00 ± 5.35	60.41–81.59	85.00 ± 4.83[b]	75.44–94.56
Cognition (0–30)	63.17 ± 5.53[a,b,d,e,f]	52.22–74.11	88.17 ± 5.78[b,d,f]	76.74–99.59	91.50 ± 5.35[b]	80.91–102.09	96.00 ± 4.83[b]	86.44–100

CI, confidence interval.
[a]Significant in post-hoc comparison with trunk control.
[b]Significant in post-hoc comparison with upper extremity (UE) motor control.
[c]Significant in post-hoc comparison with lower extremity (LE) motor control.
[d]Significant in post-hoc comparison with sensory recovery.
[e]Significant in post-hoc comparison with functional ADL.
[f]Significant in post-hoc comparison with gait recovery.
[g]Significant in post-hoc analysis with cognition.

In this study, sensory recovery continued to show a significant change over the 6-month period. Our results were similar to those of a previous study on sensory recovery by Connell *et al.* (2008). Although we did not classify responses into superficial and proprioceptive senses to investigate sensory recovery, we did compare the summed score of both senses. One interesting result from this study is the fact that the recovery of motor and sensory function did not show an interaction. This may be because the descending and ascending pathways pass through the cortex area, corona radiata, and internal capsule into the spinal cord. In addition, the majority of patients showed motor and sensory impairments at the initial assessment, suggesting that almost all patients in this study had damage to the corticospinal pathway. Winward *et al.* (2007) suggested that it is difficult to prove the relationship between functional and sensory recovery because of the variety of instrumentation and methods of evaluation used in such studies, which may create issues with inter-rater reliability; furthermore, it can be difficult to control the stimulus threshold during the sensory test if the tester is not a skilled therapist. To overcome these issues, a single experienced therapist performed a given test in all patients. In addition, decreased consciousness during the acute poststroke period could also confound sensory testing. However, the patients in this study had a relatively high score of 18.95±7.38 for cognition (Table 2). A novel finding from this study was the significant differences observed in the rates of recovery for each of the parameters. In comparison with lower leg and trunk control, the upper arm showed a lower degree of recovery (Table 4). On the basis of evidence showing the bilateral innervation of trunk musculature (Carr *et al.*, 1994), recovery of trunk control after stroke may be more favorable than recovery of the upper arm. In this study, we used the TIS to evaluate motor impairment of the trunk, and also assess static and dynamic sitting balance and trunk coordination. We observed similar degrees of recovery in the trunk and lower leg (~85%; Table 4). This could explain the relationship between the trunk and lower leg, indicating that trunk performance by TIS could demand more from the lower leg than the upper arm. Although the rate of clinical recovery is relatively rapid during 3 months after a stroke, but then slows considerably between 3 and 6 months later, we could not observe a significant difference in several recovery variables except of upper arm function at 6 months after stroke (Fig. 2). It has been suggested that muscle strength gain does not directly lead to improvement in functional performance (Bohannon, 2007), indicating that strength in different muscles is required depending on the functional activity, and that when possesses patient has some level of muscle strength, functional independence can be achieved. Furthermore, it further supports the explanation that functional independence can be achieved through repetitive training over sufficient periods of time.

Our results must be interpreted with caution because of the small sample size. It is also important to note that the limited number of participants and heterogeneity in stroke lesions may have resulted in a lack of statistical power. The study sample was a relatively younger stroke group, mean age 53.3 years. Also, in our study, the absence of additional data on sociodemographics characteristics of the enrolled population, which may have contributed toward a difference in recovery, can be considered as a limitation of the study. In addition, although one physiotherapist screened for initial inclusion criteria (i.e. motor deficits, walking disability, and community levels) and decided an enrollment of study, the lack of validated questionnaires for inclusion criteria in the stroke patients under investigation may be a limitation of the study. Nevertheless, it is still possible to draw conclusions from this small study, given the frequency and thoroughness of the assessments performed. There may be a potential effect contributing toward the functional recovery after stroke. Many factors may influence the rehabilitation course following stroke. Therefore, it is also important to mention that one of the inclusion criteria was a score on the Fugl-Meyer Assessment (arm or leg), and patients able to walk or without motor deficit of the limbs were excluded. However, generalization of the results should be performed with caution because the patients with no motor deficit and able to walk at an early stage were not included. Moreover, we did not include patients with severe communication or cognitive deficits that could interfere with evaluation; this may be the reason for the high cognition scores among the variables of clinical recovery. In addition, although we did not consider the quality of functional and gait recovery, recovery of functional performance and the achievement of independent walking occurred in most patients. Therefore, we suggest that if a patient with a certain level of cognitive ability can acquire functional independence as in the results described above, one should focus more on treatment to maximize the recovery of impairment during the early poststroke period. Still, to the best of our knowledge, this is the first long-term follow-up study that includes clinical recovery assessment for motor and sensory function, trunk balance, cognition, gait, and ADLs, enabling statistical comparison of changes in these variables after stroke.

Conclusion

This study documented and compared several parameters of stroke recovery during the period from pretreatment to 6 months after stroke, covering both the acute and the subacute phases. Recovery was relatively rapid during the first 4 weeks after treatment, and then slowed between 3 and 6 months after stroke. There appears to be a trend in which the recovery of functional performance parameters showed additional improvement during the subacute phase compared with other impairments. In comparison with lower leg and trunk control, the upper arm showed less recovery. All variables, with the exception of leg motor function between 3 and 6 months after stroke, showed continuous improvement over 6 months after stroke. Nevertheless, this study emphasizes the importance of the 3-month poststroke period for recovery; during this time, recovery variables showed improvements of 48–91% of the maximum score achieved. Thus, patients showing stagnation or deterioration at this stage should be detected early, and intensive treatments targeting motor and sensory functions soon after stroke may prove to be highly beneficial in terms of recovering from impairment and regaining functional performance. Future studies on a larger number of samples, as well as studies including brain lesions, could provide more insight into poststroke recovery and help establish effective treatment strategies. It is important to consider the many factors of recovery when considering a treatment plan in clinical settings.

Acknowledgements
Conflicts of interest
There are no conflicts of interest.

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