Predicting recovery of dextrous hand function in acute stroke

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Abstract
Purpose. To determine the clinical characteristics during acute stroke that predicted dextrous function in the paretic hand at 6 months post-stroke.
Method. Fifty-seven patients within 5 days post-stroke were recruited in stroke wards. Recovery of dextrous hand function, indicated by a score of ≥35 of Action Research Arm Test, was assessed weekly in the first 4 weeks then monthly till 6 months post-stroke. The seven predictor candidates evaluated included side and site of brain infarct, stroke severity, cognition, spatial neglect, two-point discrimination (2-PD), muscle tone and muscle strength of the paretic upper extremity (UE).
Results. Site of infarct, stroke severity, 2-PD and UE muscle strength had independent association with dextrous hand function at 6 months post-stroke. Stepwise multiple logistic regressions showed that the best early predictor was 2-PD in week 1 to 3 (Odds ratio [OR] ranged from 0.51–0.83) and UE muscle strength during the first 2 months post-stroke (OR ≥ 1.04). The strongest predictor was muscle strength at week 4 post-stroke, followed by combined 2-PD and muscle strength at week 2 post-stroke.
Conclusions. Muscle strength and 2-PD in the paretic UE during the first month post-stroke were the best predictors of dextrous hand function recovery at 6 months.

Keywords: Predictor, dextrous hand function, muscle strength, two-point discrimination, stroke

Introduction
Survivors of stroke regard upper extremity (UE) function to be important for their quality of life [1]. Previous studies of people 2–3 years after a stroke showed that 25–45% of them had experienced some return of function in the affected UE [2–4]. However, Broeks and colleagues [5] reported that 45% of subjects still showed poor UE function 4 years post-stroke. During daily activities, non-use of the paretic UE with compensation from the less affected side was common [5–6]. Delineating the key predictors of functional recovery in the paretic UE has thus aroused the interest of both clinicians and researchers.

The severity of initial motor impairment in the paretic UE is known to be prognostic for the return of muscle strength [4,7]. Some studies have also demonstrated that muscle weakness predicts later disability in performing activities of daily living assessed with the Barthel Index [8]. However, it has been difficult to interpret the exact amount of functional ability recovered, as the less affected UE was often not restricted from performing the functional tasks during assessments in these studies. Kwakkel and co-workers [9] have reported the probability of regaining dextrous hand function after 6 months in people with a flaccid UE after acute stroke. They used a score of 10 or above of the Action Research Arm Test (full score, 57) as a cut-off for dextrous hand function such as grasp, grip and pinch. However, such a low cut-off score probably only captured the presence of gross shoulder and elbow movements, which could have led to false positives for the return of grasp and pinch grips using the hand and fingers.

Apart from muscle strength, the prognostic values of other clinical variables such as the side of the stroke lesion [9,10], spatial neglect [11,12], cognition [9,13] and sensory impairments [14–16] on the
return of UE function have been controversial in the literature. In some of these studies, predictors of UE function were measured in subjects recruited at different periods ranging from 1–6 weeks after stroke onset [9,11,14]. Since substantial progress could have taken place in the early stage of stroke [17] such time variations in assessing the predictor candidates could have limited the validity of the results.

The rate of functional recovery after stroke was reported to be non-linear, being most rapid in the initial 1–3 months [4,18]. On the other hand, muscle strength in the paretic UE showed more recovery in the initial 6 months post-stroke [5]. Early predictors for dextrous hand function in the paretic UE should therefore inform treatment plans targeted at more effective recovery as well as better prognosis to recovery. This study therefore aimed to identify the best predictors of dextrous function in the paretic hand at 6 months post-stroke, from amongst a more comprehensive list of clinical variables in the first 2 months of stroke.

Method
This was a longitudinal prospective study conducted over 29 months. Ethical approval was obtained from the ethics committee of an acute and a rehabilitation hospital where subjects were recruited and followed up respectively, and the university where the study was initiated.

Subjects
Patients admitted to the acute stroke ward of a district hospital because of stroke were recruited according to the following inclusion criteria: Older than 45 years old, with first stroke from unilateral ischaemic lesion in the brain as confirmed by a CT or MRI scan and the physicians in-charge of the ward, within the first week after stroke onset, and demonstrating signs of paresis (with Motricity Index [19] score \( \leq 77 \)) in the UE contralateral to the side of brain lesion. Patients were excluded if they had reduced consciousness (Glasgow Coma Scale score < 15), were unable to express themselves in speech or to comprehend verbal or written information, were participating in other ongoing studies, had neurological signs lasting > 24 h, or had disability involving both UEs before stroke.

Dependent variable
Functional status of the paretic UE at 3 and 6 months after the onset of stroke was measured with Action Research Arm Test (ARAT) [20]. ARAT consists of 19 tasks categorized in 4 sub-tests: Grasp (6 tasks), grip (4 tasks), finger pinch (6 tasks), and gross movements of the shoulder and elbow (3 tasks). The tasks were performed solely by the paretic UE. The level of performance was rated on a 4-point scale, with 0 for inability to perform the task, 1 for partial completion, 2 for completion with abnormal synergies, and 3 for normal performance [20]. The full ARAT score was therefore 57. Its reliability and validity in measuring UE function after stroke have been well proven [21,22]. Wenzelburger and co-workers [23] had defined dextrous hand function to involve individual finger movements in reaching, grasping or gripping, and lifting of objects. In the present study, a score of 35 or above was taken to denote dextrous function with some abilities in grasp and pinch grips using the paretic hand and fingers. This score indicated that at least 17 of all the 19 tasks could be completed slowly or with abnormal synergies (with each task scoring 2) [20], but the 2 pinch grip tasks with the ring finger were not possible when the score was 1 or 0.

Candidate predictors
Eight clinical variables were selected for logistic regression analysis as follow: (i) Side and (ii) site of the brain infarct were categorized into lacunar or no obvious lesion, cortical, subcortical, or combined cortical and subcortical lesions according to CT or MRI scan reports. (iii) Severity of stroke was rated by the National Institutes of Health Stroke Scale (NIHSS) [24], with the lower scores denoting less severe stroke. (iv) Spatial neglect was evaluated by one or more lines being uncrossed in the Line-cancellation Test [25]. (v) Cognitive status was assessed by the Neurobehavioral Cognitive Status Examination [26]. This is a validated and sensitive measure for evaluating the cognitive effects of stroke, with scores \( \leq 65 \) indicating an impairment in cognition [27]. (vi) Two-point discrimination (2-PD) of the paretic UE was measured in the distal pulp of the index finger with the Diskriminator™. The latter evaluated discrimination thresholds ranging from 2–15 mm [28], with higher score indicating lower discriminative acuity. In this study, a score of 16 mm was given to subjects whose 2-PD ability was completely absent. (vii) Muscle tone of the affected UE was measured at the elbow flexors by the Composite Spasticity Scale (CSS) [29]. This is a composite measure of biceps tendon jerk and resistance to passive elbow extension on a 0–4 point scale, with the latter doubly weighted. Total scores ranging from 0–5 indicated hypotonicity, 6 indicated normal tone, and 7–12 indicated hypertonicity. The reliability of CSS has been demonstrated by our group when applied to the calf muscle [30]. Unlike the Ashworth scale which focuses almost exclusively on the manifestation of spasticity as resistance to stretch [31], the
Composite Spasticity Scale also takes into consideration hypotonicity of the muscles that is usually present in the early stage of stroke. (viii) Muscle strength of the paretic UE was measured with the Motricity Index [19]. This validated composite score assessed the strength of shoulder abduction, elbow flexion and finger pincer movement after stroke, with a score of 1 for no muscle activities, 29 for the presence of flicker of muscle contraction but no observable movements, and a full score of 100 for normal muscle strength.

Procedure

A physiotherapist screened the subjects before they signed the written informed consent form themselves or were assisted by their relatives. This was followed by an assessment of subjects’ baseline status. The assessment of the 6 candidate predictors on stroke severity (# iii above) and sensori-motor impairment of the paretic UE (# iv–viii above) were standardized according to the protocols reported in literature [19,24–29]. Another physiotherapist (the investigator SAY) reassessed subjects’ progress in sensori-motor functions weekly in the first month after recruitment and then at 2 and 6 months post-stroke. Both physiotherapists were not involved in the rehabilitation of the subjects. The test-retest and inter-rater reliability of measurements for sensation, muscle tone, muscle strength and UE functional ability were confirmed with another 21 subjects at rehabilitation or chronic stage of stroke (mean age 70.2 years, SD = 8.4). The intraclass correlation coefficients ranging from 0.91–1.00 confirmed excellent repeatability for intra- and inter-rater measurements, while the inter-rater reliability for muscle tone measurement was fairly good at 0.66.

Statistical analysis

SPSS version 11.0 for Windows was used in the data analyses. Univariate logistic regression was applied to assess the strength of association between the candidate predictors and the presence of functional dexterity in the paretic UE at 6 months post-stroke. Those candidate predictors showing independent association with the outcome (in terms of odds ratio with p-value ≤0.05) were selected for model fitting in subsequent multiple logistic regression analysis, using a backward stepwise likelihood ratio approach in 2 steps. The probability for removing candidate predictors was set at 0.051. Step 1 analysed all the predictors screened by the univariate logistic regression. Step 2 examined the effects of interactions amongst the predictors as well as model fitting. The overall strength of prediction of the candidate predictors, and the sensitivity and specificity of the prediction models were determined by analyzing the Receiver Operating Characteristics (ROC) curve. The strength of the prediction models was then compared with reference to their values of the likelihood ratio test.

Results

Seventy subjects were recruited from the acute stroke ward. Their progress was subsequently followed up in the rehabilitation hospital and in their place of residence. Thirty-one subjects were excluded in the regression analysis: Three died of stroke recurrence or complication within the first 4 months post-stroke; one had recurrent stroke at week 3 post-stroke; seven could not be contacted after discharged from the hospital; and two refused further follow-up before the assessment at week 12. With reference to the results of Chi-square statistics and independent t-tests, the demographic and baseline clinical status of the 13 dropped out subjects was not different from the 57 subjects who completed the 6-month follow-up assessments.

Table 1 presents the demographic and baseline characteristics of the 57 subjects involved in the logistic regression analysis. Their mean age was 69.7 years (SD = 10.2 years). Twenty-five subjects were female and 32 were male. The mean time of baseline assessment was 60.4 hours (SD = 25.5 hours, range = 8–134 hours) from stroke onset. Thirty-five subjects had left hemisphere stroke. The initial stroke severity ranged from mild to moderate (NIHSS range = 1–15). Forty-four percent of the subjects had spatial neglect and 58% demonstrated severe to mild cognitive impairment [26] (NCSE scores range = 20–63). Thirty-six subjects (63%) had co-morbid stroke risks [32] such as diabetes mellitus, cardiac or circulatory dysfunction. The mean total length of their hospital stay was 42 days (range = 5–75 days).

Figure 1 presents the sensory, motor and functional ability of the paretic UE of the subjects over the 6 months of assessments. With reference to the norm 2-PD threshold of the index finger pulp (mean = 3.4 mm, SD = 1.0) that was determined in 100 healthy controls (46 males and 54 females, mean age 69.1 years, SD = 8.9) recruited from 4 community centres prior to this study, 65% of the subjects had mild (30%) to severe (32%) impairment in 2-PD at baseline assessment [33]. Forty-four percent of the subjects had spasticity (Composite Spasticity Score > 6, range = 7–9) in the paretic UE, while 51% was hypotonic or flaccid (scores range 1–5). In regard to UE muscle strength, the Motricity Index scores ranged from 1–77, with a median score of 29 (51% of the subjects). This score indicated only a flicker of muscle activity in the shoulder, elbow and fingers so that movements were impossible. The median
ARAT score was 0 (range = 0–57). Forty-six subjects (81%) had poor functional ability (ARAT \leq 10) \cite{9} in their paretic UE. Only five of the 57 subjects showed dextrous hand function, with ARAT score ranging from 35–57.

Much improvement of these clinical variables was observed in the first 4 weeks. By 6 months post-stroke, 26% subjects continued to have impairment in 2-PD. Most subjects (86%) had spasticity in the paretic UE, but three still had hypotonic or flaccid UE. The median Motricity Index score for UE muscle strength was 66 (mean = 62.8, SD = 23.9) and the median ARAT score was 13.5 (mean = 25.9, SD = 25.0, range 0–57). Eighteen (32%) subjects achieved dextrous hand function while 47% remained with poor functional ability in the paretic UE.

Table II presents the results of univariate logistic regressions of candidate predictors at recruitment against the presence of dextrous hand function (ARAT \geq 35) 6 months after stroke. In such an analysis, a predictor with an odds ratio which was significant and greater than 1 predicted favourably the return of functional dexterity in the paretic UE, i.e., higher scores of the predictor was favourable to the outcome. However, those with odds ratio less than 1 indicated an adverse prognosis. The Table shows that the side of the lesion and the initial levels of cognitive impairment, spatial neglect and muscle tone were not significantly associated with the functional outcome. The four variables which showed significant associations were the site of lesion, the severity of the stroke, initial 2-PD and muscle strength in the paretic UE as measured with the Motricity Index.

The four significant baseline predictors were entered in the model fitting analysis for the 6-month functional outcomes using multiple logistic regressions and a stepwise backward likelihood ratio approach. There was no significant interaction of the predictors in terms of functional outcome. Table III describes the results of the model fitting.

At baseline assessment, muscle strength was the only predictor significantly associated with dextrous hand function at 6 months post-stroke (Odds ratio [OR] = 1.04). In the subsequent 3 weeks after stroke,
the weekly status of muscle strength (OR ranged from 1.09–1.45) and 2-PD (OR ranged from 0.51–0.83) together best predicted the functional outcome. However, by week 4 up to 2 months post-stroke, muscle strength became the only strong predictor of dextrous hand function at 6 months.

Larger values of the likelihood ratio signified greater strength of the predictor models. Muscle strength of the paretic UE at week 4 after stroke was therefore the strongest predictor of functional dexterity at 6 months post-stroke. From analysis of the ROC curves, a Motricity Index score \(C21\) for muscle strength in the paretic UE at week 4 post-stroke could be considered a cut-off threshold for the return of functional dexterity at 6 months. This indicator showed high sensitivity (1.00) and specificity (0.97) of prediction. The second best model for predicting the 6-month functional outcome included both muscle strength and 2-PD data at week 2 post-stroke, which showed sensitivity and specificity of prediction of 1.00 and 0.94, respectively. The return of dextrous hand function was predicted with a Motricity Index score \(C21\) if the 2-PD threshold was normal (3.4 mm). The results suggest that at week 2 post-stroke, statistically speaking, 1 mm loss in 2-PD acuity can be compensated by a 2 point increase in Motricity Index score in predicting the same dextrous hand function at 6 months.

### Discussion

Previous studies have shown that an adverse prognosis for UE or daily activity functions after stroke is associated with right hemispheric lesion, spatial neglect and cognitive impairment \([9,10,34,35]\). Kwakkel and co-workers \([9]\) demonstrated the prognostic value of the side of stroke and spatial neglect using a homogeneous group \((n = 102)\) having poor UE function \((ARAT < 10)\). In their study, subjects with right hemispheric strokes outnumbered those with left hemispheric strokes by 3 to 2, with half of them suffering from spatial neglect. In the present study, 46 subjects demonstrated poor UE function at recruitment. Amongst them, 39% had suffered right-hemispheric strokes and 41% of them had spatial neglect. The return of functional dexterity denoted by a much higher ARAT score \((\geq 35)\) was not significantly associated with the side of the stroke lesion, or with initial spatial neglect. Although spatial neglect and cognition were reported to predict

### Table II. Association of the candidate predictors at recruitment with recovery of dextrous hand function (ARAT \(\geq 35\)) at 6 months post-stroke.

<table>
<thead>
<tr>
<th>Predictor candidates</th>
<th>6-month Functional Outcome</th>
<th>Odds Ratio (95% C.I.)</th>
<th>p</th>
<th>C.I., confidence interval. *Denotes values being significant at the (p \leq 0.05) level in univariate binary logistic regression.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemispheric lesion (with reference to right-sided lesion)</td>
<td></td>
<td>1.81 (0.59–5.51)</td>
<td>0.300</td>
<td></td>
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<tr>
<td>Site of lesion:</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Cortical</td>
<td></td>
<td>0.46 (0.07–3.09)</td>
<td>0.420</td>
<td></td>
</tr>
<tr>
<td>Subcortical</td>
<td></td>
<td>0.18 (0.05–0.69)</td>
<td>0.013*</td>
<td></td>
</tr>
<tr>
<td>Cortical &amp; Subcortical</td>
<td></td>
<td>0.09 (0.01–1.00)</td>
<td>0.050*</td>
<td></td>
</tr>
<tr>
<td>Stroke severity</td>
<td></td>
<td>0.72 (0.57–0.92)</td>
<td>0.008*</td>
<td></td>
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<tr>
<td>Cognition</td>
<td></td>
<td>1.02 (0.98–1.06)</td>
<td>0.364</td>
<td></td>
</tr>
<tr>
<td>Spatial neglect</td>
<td></td>
<td>0.97 (0.34–2.83)</td>
<td>0.962</td>
<td></td>
</tr>
<tr>
<td>Sensation: Two-point discrimination</td>
<td></td>
<td>0.85 (0.75–0.96)</td>
<td>0.005*</td>
<td></td>
</tr>
<tr>
<td>Upper extremity muscle tone</td>
<td></td>
<td>1.06 (0.85–1.32)</td>
<td>0.585</td>
<td></td>
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<tr>
<td>Upper extremity muscle strength</td>
<td></td>
<td>1.04 (1.02–1.07)</td>
<td>0.001*</td>
<td></td>
</tr>
</tbody>
</table>

### Table III. Best early predictors for functional dexterity at 6 months post-stroke.

<table>
<thead>
<tr>
<th>Best predictors</th>
<th>Odds Ratio</th>
<th>Likelihood Ratio test</th>
<th>p *</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline: Muscle strength</td>
<td>1.04</td>
<td>13.34</td>
<td>0.000</td>
<td>0.78</td>
<td>0.71</td>
</tr>
<tr>
<td>Week 1 post-stroke:</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Muscle strength</td>
<td>1.09</td>
<td>24.62</td>
<td>0.000</td>
<td>0.74</td>
<td>1.00</td>
</tr>
<tr>
<td>Two-point discrimination</td>
<td>0.83</td>
<td>6.12</td>
<td>0.013</td>
<td></td>
<td></td>
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<tr>
<td>Week 2:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Muscle strength</td>
<td>1.45</td>
<td>53.12</td>
<td>0.000</td>
<td>1.00</td>
<td>0.94</td>
</tr>
<tr>
<td>Two-point discrimination</td>
<td>0.51</td>
<td>8.76</td>
<td>0.003</td>
<td></td>
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<tr>
<td>Week 3:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle strength</td>
<td>1.15</td>
<td>36.10</td>
<td>0.000</td>
<td>1.00</td>
<td>0.91</td>
</tr>
<tr>
<td>Two-point discrimination</td>
<td>0.74</td>
<td>4.65</td>
<td>0.031</td>
<td></td>
<td></td>
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<tr>
<td>Week 4:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Muscle strength</td>
<td>454220.78*</td>
<td>74.11</td>
<td>0.000</td>
<td>1.00</td>
<td>0.97</td>
</tr>
<tr>
<td>2 months:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle strength</td>
<td>1.27</td>
<td>56.96</td>
<td>0.000</td>
<td>1.00</td>
<td>0.88</td>
</tr>
</tbody>
</table>

C.I., confidence interval; UE, upper extremity; *Denotes significance at \(p \leq 0.05\) in a likelihood ratio test of a multiple logistic regression analysis using the backward likelihood ratio approach; \(^*\)Denotes that a prediction from UE muscle strength at a cut-off Motricity Index score of 64 clearly demarcates subjects in favour of the presence of functional dexterity (Action Research Arm Test score \(\geq 35\)) at 6 months post-stroke.
recovery of daily activity functions [34,35], we could not demonstrate their association with dextrous hand function. This was probably related to the nature of the UE tasks which did not demand planning or problem-solving abilities. The different findings indicate the need for further investigation of the 3 predictor candidates with a larger sample consisting of a more even mix of side of brain lesion.

A subcortical lesion or a large brain infarct involving both cortical and subcortical structures was found to be marginally significant for predicting functional recovery in the paretic UE at 6 months after stroke ($p = 0.013$ and 0.050, respectively; Table II). Previous studies have shown that people with total anterior circulation infarcts or lesions involving subcortical structures can expect less UE motor recovery [8,14,36]. Using neuroimaging techniques to diagnose acute capsular stroke, Wenzelburger and colleagues [23] found that lesions in the posterior regions of the internal capsule were associated with chronic dexterity deficits in the affected UE. In the present study, this association could not be demonstrated in the multiple regression analysis. It could be argued that the results have been limited by the small sample of subjects with subcortical lesions.

Severity of stroke has been found to predict the recovery of patients’ abilities in their activities of daily living [37]. However, whether it might also predict the recovery of functional dexterity had never been examined before this study. Our results showed that severity of stroke had an independent association with the functional outcome of the paretic UE, but its strength of prediction became non-significant after adjusting for the effects of other predictors. One reason could be the high correlation between severity of stroke and muscle strength in the paretic UE. Nevertheless, the results highlight the need to control for possible confounding effects of stroke severity in clinical trials.

Muscle tone is often considered crucial in governing the recovery of UE motor function [38]. In the classic observational study on the recovery of motor function after stroke, Twitchell [39] commented that early return of finger jerk was prognostic to motor recovery. Examining 95 patients in the first 3 months post-stroke, Sommerfeld and colleagues [40] found that muscle tone was only weakly associated with the ability to perform motor tasks. In our study, most of the subjects who received conventional rehabilitation had increase in UE muscle tone with time. Eighty-five percent of subjects ($n = 48$) presented with spasticity (Composite Spasticity score >6) in the paretic UE by 2 months post-stroke. The present result showed that muscle tone in the early post-stroke period did not predict the recovery of dextrous hand function ($p > 0.1$, Table II). During the early stage of rehabilitation, treatment emphasis on muscle tone should be reviewed if recovery of functional dexterity is the ultimate goal [41].

Our results show that strength in the paretic UE was the only consistent early predictor for its functional recovery at 6 months after stroke onset (Table III). In addition to UE muscle strength, the prediction models in the initial 3 weeks post-stroke also included a significant role for 2-PD threshold in the paretic hand. The prediction at week 2 was the second strongest after the week 4 model. Duncan and colleagues [17] have reported that motor and sensory scores on the Fugl-Meyer Assessment at day 5 after stroke together accounted for 74% of the variance in the composite scores at 6 months post-stroke. However, it is not possible to delineate the contribution of UE sensation to the recovery of dexterous hand function from such composite scoring of the sensori-motor functions in both upper and lower extremities. Other reports on the predictive value of sensation for UE recovery have not provided a clear description of the sensory modality or the method of measurement [7,11,14]. Kwakkel and colleagues [9] did not find UE proprioception measured by locating the affected thumb in space to be associated with the recovery of UE function at 6-month post-stroke. In contrast, Prescott and colleagues [16] showed UE position sense to be predictive of independence in daily activities. Note that deficits in position sense had been reported to be less prevalent than deficits in 2-PD after stroke [33], which could have made position sense less sensitive in prediction, leading to the contradictory results reported by different investigators.

Up to present, many therapies for the paretic UE have been targeted at improving motor impairments in the extremity [42–45]. Sensory discrimination in the hand is crucial for fine manual skills [46,47]. Tactile afferent signals in the hand guide the force control of precision grip [48]. Complex movements become difficult to perform when perception of such sensation is degraded, especially in the absence of visual guidance [46]. Recently, post-stroke brain imaging studies have revealed early sensory and motor cortical reorganization ipsilateral and contralateral to the stroke lesion before clinical recovery became obvious [49,50]. In human, neuro-plasticity has been shown to be associated with sensori-motor experience [51]. Compensatory use of the less involved extremity at an early stage could deprive the paretic UE of practice necessary for sensory, motor and functional improvement. Being a significant and strong early predictor of later recovery in functional dexterity after stroke, 2-PD impairment in the affected hand should be addressed early in rehabilitation during the first month post-stroke.
Compared to the strength of prediction of muscle strength and 2-PD in the paretic UE in the first month, muscle strength 2 months after stroke was, however, weaker as a predictor of functional dexterity. These results support the suggestion that treatment during a 1-month time window from stroke onset is crucial to recovery [18,39]. This study has explicitly identified 45 and 64 as the Motricity Index cut-off scores at week 2 and week 4 post-stroke being predictive of functional recovery at 6 months. This level of muscle strength could serve as a goal for treatments targeted to recover functional dexterity in stroke patients.

**Conclusion**

In people who have suffered mild to moderately severe stroke at onset, muscle strength and 2-PD in the paretic UE in the first month post-stroke are the best early predictors of the recovery of dextrous hand function at 6 months.

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