



Summary

PART ONE

Stroke is one of the main health problems in the Western world. Eighty percent of stroke survivors have motor impairments, such as upper or lower limb hemiparesis. These motor impairments greatly affect an individual's ability to perform activities of daily living (ADL). In particular, the severity of an upper limb paresis is strongly associated with ADL independency and quality of life. Because of the ageing population, the number of stroke patients is predicted to increase in the future. Hence, the efficiency of care needs to be improved. Adequate prognostic information about upper limb recovery can improve the efficiency of stroke care. It is important for stroke management decisions, like discharge policies and intervention planning at hospital stroke units and in integrated care pathways. The first part of this thesis was therefore aimed at investigating prospectively if outcome of the paretic upper limb can be predicted, already in the hospital stroke unit.

In **Chapter 2**, the development of a computational prediction model for outcome of the paretic upper limb at 6 months after stroke is presented. Candidate prognostic determinants were measured in 188 stroke patients, within 72 hours and at 5 and 9 days post stroke. Outcome of the paretic upper limb at 6 months was measured with the Action Research Arm Test (ARAT). Final outcome was dichotomized into 1 for those who regained some dexterity (≥ 10 points on ARAT) and 0 for those who did not regain any dexterity (< 10 points on ARAT). Logistic regression analysis was used for model development. It was shown that accurate prediction of upper limb recovery at 6 months is already possible within 72 hours after stroke onset by using two simple bed-side tests, 'finger extension' and 'shoulder abduction'. Patients who were able to exhibit some voluntary extension of the fingers and some abduction of the hemiplegic shoulder within 72 hours had a probability of 0.98 to regain some dexterity at 6 months, whereas the probability was 0.25 for those without this voluntary motor activity. Retesting the model on days 5 and 9 resulted in a gradual decline in probability from 0.25 to 0.14 for those without finger extension and shoulder abduction, whereas the probability remained 0.98 for those with this motor activity. The increased accuracy of prediction when time progresses is probably reflective of the gradual decline of uncertainty as a result of time-dependent spontaneous processes of recovery after stroke.

In **Chapter 3** recovery of upper limb capacity after stroke was investigated when patients were discharged from the hospital stroke unit, during their inpatient rehabilitation phase. In 299 stroke patients, upper limb capacity was measured using the Stroke Upper Limb Capacity Scale (SULCS). Patients were assessed on admission to rehabilitation centre and again at discharge. On the basis of admission SULCS scores of patients were categorized into 3 groups; no hand



capacity (SULCS 0–3); basic hand capacity (SULCS 4–7) and advanced hand capacity (SULCS 8–10). Of the 125 patients who had no hand capacity at admission, 59% had not regained any hand capacity at discharge, whereas 41% regained at least basic hand capacity at discharge. The SULCS score at discharge was largely explained by the SULCS score at admission. It was found that patients without hand capacity, but with some elbow and shoulder control (SULCS 2–3) on admission still have a fair chance to regain at least some hand capacity. Patients without proximal control (SULCS 0–1) have a poor prognosis to regain some hand capacity.

In **Chapter 4** the accuracy of predictions made by physical therapists (PTs) regarding upper limb recovery was compared with the accuracy of a derived computational model. Predictions were made within 72 hours after stroke onset as well as on the moment of discharge from the hospital stroke unit. For 131 stroke patients, 20 PTs made predictions about upper limb recovery in 3 categories; the patient will not regain any dexterity (ARAT 0–9); the patient will regain some dexterity and (ARAT 10–56); the patient will regain full recovery (ARAT 57). Computational prediction models, developed using ordinal logistic regression analyses were used to predict upper limb recovery in the same 3 categories. The accuracy of predictions, made within 72 hours after stroke, was significantly lower when made by the PTs than when made by the computational prediction model. The accuracy of prediction, made at the moment of discharge was, however, similar for PTs and the model.

PART TWO

The second part was aimed at gaining more insight into the effectiveness of Constraint Induced Movement Therapy (CIMT) and modified versions of CIMT (mCIMT). (m)CIMT includes 3 main elements: repetitive, task-oriented training of the more affected upper limb, constraining the less affected upper limb and a transfer package of adherence-enhancing behavioural methods. The effectiveness for (m)CIMT is well established when applied beyond 3 months after stroke onset. The effectiveness of (m)CIMT started within the first 3 months post stroke is however still controversial.

In **Chapter 5** of this thesis a systematic review on the current evidence for (m)CIMT in the first 10 weeks post stroke is presented. Studies were pooled by calculating Mean Differences (MD). Since the optimal dose of (m)CIMT, started in the first weeks post stroke is particularly debated in the literature, separate quantitative analyses for High Intensity (HI) CIMT (at least 3 hours of repetitive training) and Low Intensity (LO) CIMT (less than 3 hours of repetitive training) were applied. Five randomized controlled trials were included, comprising 106 participants. The meta-analysis demonstrated significant MDs in favor of CIMT for the Fugl-Meyer arm,



the ARAT, the Motor Activity Log (MAL): Quality of Movement and the Grooved Pegboard Test. Non-significant MDs in favor of CIMT were found for the MAL: Amount of Use. Results of separate analyses for HI and LO CIMT suggest that LO CIMT may be more beneficial when started in the first weeks after stroke than HI CIMT.

The package of CIMT and modified versions of CIMT (mCIMT), applied in the first 10 weeks after stroke is heterogeneous and the exact content is often indistinct in the literature. In line with the need for transparency regarding the content of therapy in rehabilitation trials, the mCIMT protocol, developed for the EXPLICIT-stroke programme is presented in **Chapter 6**. According to this protocol, repetitive task training is applied for 1 hour per working day, and the patients wear a mitt for at least 3 hours per day. The intervention starts within 2 weeks after stroke onset and is continued for 3 consecutive weeks. The modified protocol retains 2 of the 3 key elements of the original CIMT protocol, i.e. repetitive training and the constraining the less affected upper limb. In addition, the protocol emphasizes restoration of body functions, whilst preventing the development of compensatory movement strategies. More specifically, the intervention aims to improve active wrist and finger extension, as key factors for upper limb recovery.

PART THREE

A proper measurement tool is required to evaluate the effectiveness of (m)CIMT or any other intervention. The ARAT and the Wolf Motor Function Test (WMFT) are the most commonly used assessments for the paretic upper limb that are aimed to quantify upper limb performance during unilateral motor tasks.

In **Chapter 7**, the concurrent validity between the ARAT and the WMFT was investigated. In addition their reproducibility, internal consistency and floor and ceiling effects in the same sample of stroke patients were compared. A spearman rank correlation coefficient of 0.86 between the ARAT total score and the WMFT functional ability score was found, suggesting a high concurrent validity. Intraclass Correlation Coefficients (ICCs) for inter-rater and intra-rater reliability ranged from 0.92 to 0.97 respectively. Bland Altman analysis showed a less stable way of scoring for the WMFT, compared to the ARAT and internal consistency (Cronbach's alpha) was >0.98 for both scales, suggesting that both measurement tools measure a single, unidimensional construct. Finally, no floor and ceiling effects were found. It can be concluded that the ARAT and the WMFT are comparable measurement tools aimed to quantify upper limb capacity after stroke.

