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ORIGINAL ARTICLE

Predicting Clinically Significant Changes in Motor and Functional Outcomes After Robot-Assisted Stroke Rehabilitation

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Abstract

Objective: To investigate the predictors of minimal clinically important changes on outcome measures after robot-assisted therapy (RT).

Design: Observational cohort study.

Setting: Outpatient rehabilitation clinics.

Participants: A cohort of outpatients with stroke (N=55).

Interventions: Patients with stroke received RT for 90 to 105min/d, 5d/wk, for 4 weeks.

Main Outcome Measures: Outcome measures, including the Fugl-Meyer Assessment (FMA) and Motor Activity Log (MAL), were measured before and after the intervention. Potential predictors include age, sex, side of lesion, time since stroke onset, finger extension, Box and Block Test (BBT) score, and FMA distal score.

Results: Statistical analysis showed that the BBT score (odds ratio[OR]=1.06; P=.04) was a significant predictor of clinically important changes in the FMA. Being a woman (OR=3.9; P=.05) and BBT score (OR=1.07; P=.02) were the 2 significant predictors of clinically significant changes in the MAL amount of use subscale. The BBT score was the significant predictor of an increased probability of achieving clinically important changes in the MAL quality of movement subscale (OR=1.07; P=.02). The R^2 values for the 3 logistic regression models were low (.114–.272).

Conclusions: The results revealed that patients with stroke who had greater manual dexterity measured by the BBT appear to have a higher probability of achieving clinically significant motor and functional outcomes after RT. Further studies are needed to evaluate other potential predictors to improve the models and validate the findings.

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Robot-assisted therapy (RT) shows great promise as a treatment for stroke patients and has gained increasing popularity in the last 15 years.[1-5] The use of robotics in rehabilitation is a relatively new approach that transfers scientific concepts to clinical practice for assisting disabled people.[6,7] Robot-assisted devices generally have several, or possibly all, of the following components: power supply system, mechanical system, robot manipulators, actuators,

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sensors, data processing unit, computer program, control system, and software. In this study, an end-effector robot-assisted device in which the robot moves the manipulators by putting force on the patient's hand was used to provide arm exercise for patients. It is primarily equipped with computerized control movement modes, adjustable movement parameters, sensors, and a computer game.

RT incorporates key elements of motor learning into treatment, including highly intensive, task-specific, reproducible, and interactive practice. Cumulative research evidence and systematic reviews support the efficacy of upper limb RT for improving motor and functional outcomes in stroke patients.[8,9] Despite the growing popularity of RT for stroke rehabilitation, the characteristics of patients who might benefit most from this therapy remain understudied.[10] Many interacting factors may affect outcomes of stroke rehabilitation,[11] but little is known about the factors that may predict treatment outcomes of RT. Identification of predictors may help to tailor treatment plans and more accurately stratify patients toward a better outcome after RT.

This study attempted to identify the predictors of RT outcomes to help target the individuals who would benefit most from this intervention. Seven candidate predictors were selected because they demonstrated predictive value in stroke rehabilitation research[12-16]: age, sex, side of lesion, time since stroke onset, finger extension, Fugl-Meyer Assessment (FMA) distal score, and Box and Block Test (BBT) score.

The predictors can be grouped into 2 main types: those represented or measured by baseline descriptive characteristics (eg, age, sex, side of lesion, and time since stroke onset) and those related to hand function (eg, finger extension, FMA distal score, and BBT score, which measures manual dexterity). Previous studies have identified that many of these factors predict or influence motor and functional outcomes after specific rehabilitation interventions.[13-16] Patients with higher distal arm function (eg, wrist and hand) benefitted more from treatment; however, whether these factors also influence RT outcomes requires further investigation.

The present study examined the prognostic values of these factors on RT outcomes by using a robot-assisted arm trainer for wrist and forearm movements. Several RT studies indicated that when robotic devices specifically focus on distal arm training, there is a generalization effect on other parts of the upper arm.[1,17,18] The objectives of this study were to determine what factors significantly predicted the probability of achieving clinically important changes after RT on motor and functional outcomes, as defined by the FMA and the Motor Activity Log (MAL), respectively.

Methods

Participants

Study participants were enrolled to investigate the treatment efficacy of RT after stroke.[2,19] The analysis included 55 patients (35 men and 20 women) with no missing data on the outcome measures. Table 1 outlines the baseline characteristics of participants, who were an average age of 54 years (range, 23−77y). The mean time from stroke onset to recruitment was 24 months. The inclusion criteria were (1) experienced a unilateral stroke at least 6 months previously, (2) an FMA upper limb score of 26 to 56, (3) no excessive spasticity in the forearm and wrist joints (Modified Ashworth Scale score <3), (4) able to follow study instructions and perform study tasks (Mini-Mental State Examination ≥22),[20,21] (5) had not had a fracture within the previous 3 months and did not have painful arthritis of the joints or painful injuries in the upper limbs, and (6) had no severe neuropsychological impairments (eg, global aphasia or severe attention deficits). The institutional review boards of the participating hospitals approved the trials, and all participants provided informed consent.

Study design

This was an observational cohort study that used secondary analysis of data to identify the significant predictors of RT treatment outcomes for patients with stroke.

Procedure

Participants were treated with RT for 90 to 105min/d, 5d/wk, for 4 weeks. The intervention was administered by certified occupational therapists. The same blinded rater administered the outcome measurements in all patients before and after treatment.

Participants received an RT intervention using the Bi-Manu-Track robot-assisted arm trainer.[a] The Bi-Manu-Track enables wrist flexion-extension and forearm pronation-supination movements in 3 computer-controlled modes: passive-passive, active-passive, and active-active. Within each session, the participant practiced the passive-passive and active-passive modes for 15 to

Table 1 Baseline characteristics of the study participants (N=55)

Characteristics	Value
Age (y)	53.92±11.44
Time after stroke (mo)	23.96±14.97
Sex	
Male	35 (63.6)
Female	20 (36.4)
Side of stroke	
Right	31 (56.4)
Left	24 (43.6)
Stroke type	
Ischemic	35 (63.6)
Hemorrhagic	20 (36.4)
Assessment scores	
MMSE	28.05±2.32
FMA	42.96±8.66
MAL AOU	0.66±0.64
MAL QOM	0.73±0.64
FMA distal	12.09±6.13
BBT	13.76±11.53

NOTE. Values are mean ± SD or n (%).
Abbreviation: MMSE, Mini-Mental State Examination.

List of abbreviations:

AOU	**amount of use**
BBT	**Box and Block Test**
FMA	**Fugl-Meyer Assessment**
MAL	**Motor Activity Log**
QOM	**quality of movement**
RT	**robot-assisted therapy**
VIF	**variance inflation factor**