EUR J PHYS REHABIL MED 2008;44:431-5

Robot-assisted therapy for neuromuscular training of sub-acute stroke patients. A feasibility study

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Aim. **Several studies have described the contribution of robotics technology in providing effective treatment options for improving upper-extremity functions in patients with hemiparesis following stroke. The aim of this study was to conduct a preliminary assessment of patient acceptance of an upper extremity robot, the Reo™ Therapy System (Motorika Ltd., Israel), developed specifically for neuromuscular training of upper extremities for use in rehabilitation centers and outpatient clinics.**
Methods. **Ten in-patient sub-acute stroke patients aged 30-60 years participated in the study. They received 15 sessions of forty five minutes training with the Reo™ Therapy System, in addition to traditional occupational and physical therapy. A feedback questionnaire of the patients' satisfaction, the Fugl-Meyer test and the Manual Function Test (MFT) were used as outcome measures.**
Results. **Patient satisfaction with the robot-assisted therapy program and acceptance of working with Reo™ Therapy System was very good. Arm impairment and functionality as measured with the Fugl-Meyer and the MFT increased significantly after treatment.**
Conclusion. **The Reo™ Therapy System was found to be valued by patients. Further research is necessary in order to identify the most efficient balance of Reo Therapy and traditional therapy methods.**

KEY WORDS: Rehabilitation - Paresis - Stroke - Robotics.

Loss of arm function after stroke is one of its most devastating effects, as the affected limb may cause severe disablement in daily life.[1-3] Several studies have described the contribution of robotics technology in providing effective treatment options for improving upper-extremity functions in patients with hemiparesis following stroke.[4, 5] Rather than using robotics as an assistive technology for a disabled individual, research focus is on the development and application of robotics as a therapy aid, and in particular a tool for therapists.[6] The investigators foresee robots and computers as supporting and enhancing the productivity of clinicians in their efforts to facilitate a disabled individual's functional motor recovery.[7] The development of robotic treatments is motivated by the increasing public health burden associated with stroke-related disability, and by the current emphasis on health care cost reductions, which have resulted in shorter length of stay for inpatient rehabilitation.[8, 9]

The purpose of this study was to conduct a preliminary assessment of patient acceptance of the Reo™ Therapy System, a robot-assisted therapy that was developed specifically for motor training of the upper extremity in post-stroke patients in inpatient rehabilitation centers and outpatient clinics (Figure 1).

Received on August 28, 2008.
Accepted for publication on June 13, 2008.

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Figure 1.—The Reo™ Therapy System.

Materials and methods

Subjects

Ten sub-acute stroke patients aged 30-60 years (mean ± SE, 50.4±10.1 years; one of them female, all but one right-handed) participated in the study. All signed written informed consent according to the Declaration of Helsinki, and the Loewenstein Rehabilitation Center Institutional Review Board (IRB) approved the study protocol. Patients started the treatment about 7 weeks after stroke onset (mean ± SE, 7±1.8 weeks).

Inclusion criteria was: a hemiparesis of the upper extremity; diagnosis of a first clinically apparent 3 weeks and 3 months prior to study entry; age between 18 and 75 years and ability to sit and be active for an hour on a chair (or wheelchair) without cardiac, respiratory and/or pain disturbances. Exclusion criteria was: recurrent stroke, or intracerebral hemorrhage; severe pain with passive motion of the affected shoulder or elbow; other neurological or musculoskeletal target organ disorder; inability to give informed consent personally.

Intervention

Patients received 45 minutes/day of robot-assisted treatment in addition to the standard daily rehabilitation sessions. The robot treatment was administered 5 days a week for 3 weeks. All patients were treated intensively by a multidisciplinary rehabilitation team under the supervision of a physiatrist for not less than 3 hours a day, 5 days a week in the physiotherapy, occupational and speech therapy departments.

The robotic assistance device used in this study was the Reo™ Therapy System (Motorika Medical [Israel] Ltd., Israel). In this robot-assisted therapy a robot manipulator applies forces to the more affected forearm during goal-directed movements. During the treatment the patient's affected hand is placed on or strapped onto the robotic arm and the patient is instructed to either actively reach predefined reach points, or to be guided while the robotic arm leads his/her arm towards these reach points (Figure 2). The patient was instructed to perform reach movements with the dynamic help of the ReoTM Therapy System. The distance of the reach movements was defined for each patient according to his/her upper-limb motor ability/impairment. A basic target of different distances was presented on a computer screen to the patient, who moved a pointer into the target. Targets, directions and patient's success were always visible and presented dynamically on the computer screen which provided visual and auditory feedback to the patient.

Outcome measures

A feedback questionnaire, which measured the patients' satisfaction with the robot-assisted therapy, was administered after one week and three weeks of treatment. The feedback questionnaire included 15 items. The patients were asked about their filings during training sections with robot, their willing to continue the treatment and their impression about the effectiveness of training for the arm function improvement. It focused on the improvement in confidence in

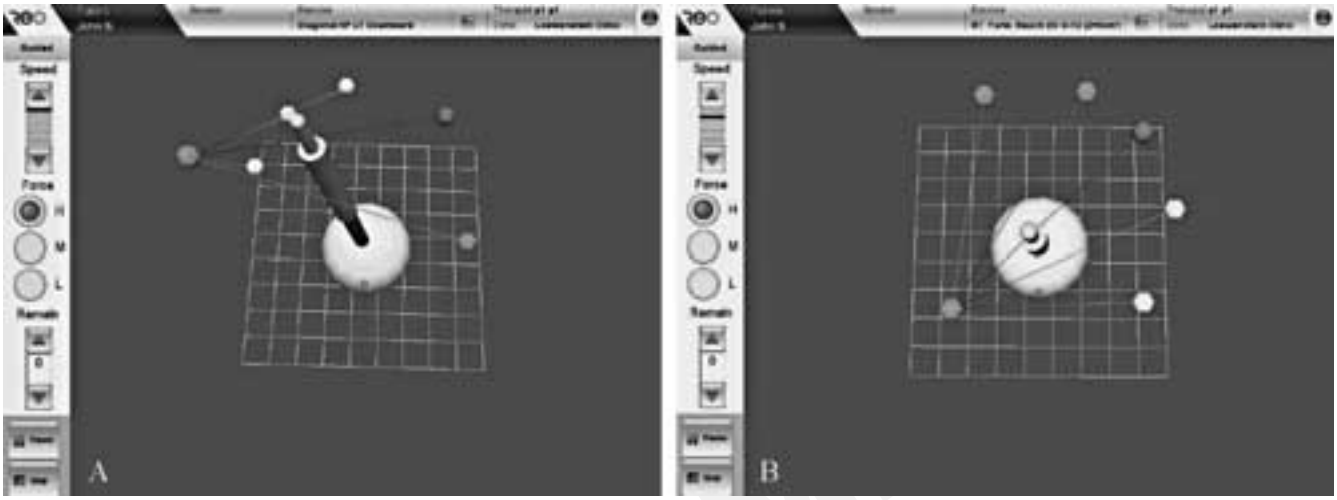

Figure 2.—Examples of the ReoTherapy exercises used in the study.

TABLE I.—*Results of acceptance feedback questionnaire, Fugl-Meyer and Manual Function Test.*

	Mean values		P values
	After 1 week of treatment	After 3 weeks of treatment	
Acceptance of Reo™ Therapy System Feedback Questionnaire (max. value = 75)	54	65	0.006*
	Pretreatment	Post-treatment	
Fugl-Meyer Test	35.0	43.5	0.001*
Manual Function Test (proximal part only)	8.2	10.3	0.01*
Manual Function Test (distal part only)	5.0	8.7	0.005*
Manual Function Test (overall)	13.2	19.0	0.002*

*Statistically significant.

using the affected arm during and after robotic treatment, and on the increase in motivation to do the robotic treatment. Answer possibilities ranged from 1 for "Not agree at all", to 5 "Very much agree" (Max value 75 points). Arm impairment and functionality was assessed with the standard Fugl-Meyer test [10] and the Manual Function Test [11] at the beginning and end of treatment.

Statistical analysis

Statistical analysis was performed with the use of Statistix software (Statistix for Windows 2.0, 1985, 98 Analytical Software) for analyzing the changes of values during the treatment. A P value <0.05 was considered significant.

Results

Patient satisfaction with the robot-assisted therapy program and acceptance of working with Reo™ Therapy System as measured by Feedback Questionnaire, increased significantly during the 3 weeks of the feasibility study period (Table I).

Patient compliance throughout the cycle of sessions was very good. All patients participated in all 15 sessions.

No untoward effects were registered, and no patients reported pain or discomfort at any stage.

Arm impairment and functionality as measured with the Fugl-Meyer and the Manual Function Test increased significantly after 15 sessions of working with the Reo™ Therapy System (Table I, Figures 3, 4).

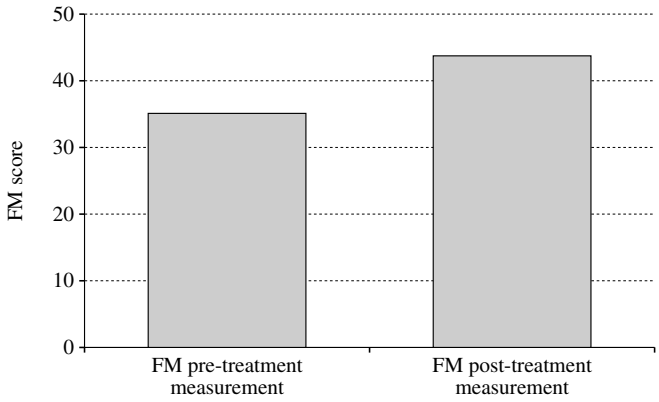

Figure 3.—Fugl-Meyer values.

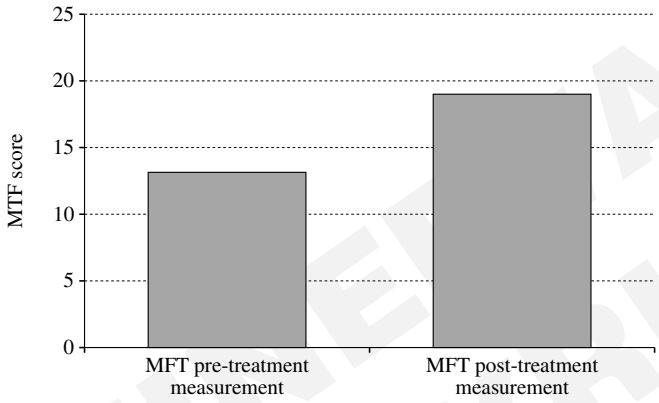

Figure 4.—Manual Function Test values.

Discussion

The use of robot-assist devices in the rehabilitation of impaired upper extremity function after stroke is widely discussed in the different studies.[12, 13] Robot training supplement the standard poststroke multidisciplinary rehabilitation programs, and past pilot and follow-up studies demonstrated beneficial effects on upper limb motor recovery.[1, 7]

Computerized robot arm training is the real challenge in rehabilitation and the interaction between the patient, technology and the stuff was always the problematic issue.[2, 6, 14]

The aim of this study was to access the acceptance of new robot for arm rehabilitation and the results showed that the use of this system was associated with high patient's satisfaction. Moreover, and even though evaluating improvement of upper extremity motor functions was not the primary goal of this study, the results of the Fugl-Meyer and the Manual Function Test clearly suggest that motor impairment and functionality was improved by robot-assisted upper arm therapy. The preliminary results can strengthen the optimistic data from other studies about the effectiveness of robot therapy in arm rehabilitation after stroke.[15]

Conclusions

In this feasibility study the authors demonstrated that the positive attitude of stroke patients toward robotic treatment increased during the treatment period. The Reo™ Therapy System was found to be valued by patients.

This positive patient response led to excellent compliance, which led to the achievement of a high number of repetitions of functional movements per session. Further research is necessary in order to identify the most efficient balance of Reo Therapy and traditional therapy methods.

References

1. Krebs HI, Mernoff S, Fasoli SE, Hughes R, Stein J, Hogan N. A comparison of functional and impairment-based robotic training in severe to moderate chronic stroke: A pilot study. NeuroRehabilitation 2008;23:81-7.
2. Hesse S, Schmidt H, Werner C, Rybski C, Puzich U, Bardeleben A. A new mechanical arm trainer to intensify the upper limb rehabilitation of severely affected patients after stroke: design, concept and first case series. Eura Medicophys 2007;43:463-8.
3. Hogan N. Increasing productivity and quality of care: robot-aided neuro-rehabilitation. J Rehabil Res Dev 2000;37:639-52.
4. Hesse S, Schmidt H, Werner C, Bardeleben A. Upper and lower extremity robotic devices for rehabilitation for studying motor control. Curr Opin Neurol 2003;16:705-10.
5. Fasoli SE, Krebs HI, Stein J, Frontera WR, Hughes R, Hogan N. Robotic therapy for chronic motor impairments after stroke: follow-up results. Arch Phys Med Rehabil 2004;85:1106-11.
6. Krebs HI, Ferraro M, Buerger SP, Newbery MJ, Makiyama A, Sandmann M *et al*. Rehabilitation robotics: pilot trial of a spatial extension for MIT-MANUS. Neuroengineering Rehabil 2004;1:5-9, 2004
7. Hogan N, Krebs HI. Interactive robots for neuro-rehabilitation. Res Neurol Neurosi 2004;22:349-58.
8. Masiero S, Celia A, Armani M, Rosati G. A novel robot device in rehabilitation of post-stroke hemiplegic upper limbs. Aging Clin Exp Res 2006;18:531-5.
9. Sanchez RJ, Liu J, Rao S, Shah P, Smith R, Rahman T *et al*. Automating arm movement training following severe stroke: functional exercises with quantitative feedback in a gravity-reduced environment. IEEE Trans Neural Syst Rehabil Eng Sep 2006;14:378-89.
10. Gladstone DJ, Danells CJ, Black SE. The Fugl-Meyer assessment of

motor recovery after stroke: a critical review of its measurement properties. Neurorehabil Neural Repair 2002;3:232-40.
11. Michimata A, Kondo T, Suzukamo Y, Chiba M, Izumi S. The manual function test: norms for 20- to 90-year-olds and effects of age, gender, and hand dominance on dexterity. Tohoku J Exp Med 2008;214:257-67.
12. Masiero S, Celia A, Armani M, Rosati G, Tavolato B, Ferraro C *et al.* Robot-aided intensive training in post-stroke recovery. Aging Clin Exp Res 2006;18:261-5.
13. Liebermann DG, Buchman AS, Franks IM. Enhancement of motor rehabilitation through the use of information technologies. Clin Biomech 2006;21:8-20.
14. Voelker R. Rehabilitation medicine welcomes a robotic revolution. AMA 2005;294(10):1191-5.
15. Hesse S, Werner C, Pohl M, Rueckriem S, Mehrholz J, Lingnau ML. Computerized arm training improves the motor control of the severely affected arm after stroke: a single-blinded randomized trial in two centers. Stroke 2005;36:1960-6.