Effects of Upper Limb Robot Therapy on the Function of Upper Limb in Patients with Hemiplegia; pilot study

Dong-Geol Lee PT, PhD[1], **Kyoung-Bo Lee PT, PhD**[2], **Young-Dong Kim PT, DPT**[*3]

[1]*Department of Physical Therapy, Degenerated Arthritis Center,*
[2]*Department of Rehabilitation Medicine, St. Vincent's Hospital,*
College of Medicine, The Catholic University of Korea, Republic of Korea,
[*3]*Department of Physical Therapy, Woosong University*

Purpose This study was to determine the effect of Upper limb robot therapy (ULRT) on upper limb function in stroke patients. ***Methods*** The subjects of this study were 3 male hemiplegic patients who voluntarily consented to participate in the study. They were received general training and ULRT during 30 minutes for each session, 5 times a week for a month. Upper limb function was evaluated by InMotion™ rehabilitation robot program and manual function test. ***Results*** The results of evaluation in 3 patients showed significant differences in Robot Initiation, Robot Power and Motion Jerk between pre and post test. ***Conclusion*** This study suggested that ULRT was effective in improvement of muscle power, flexibility and function of the upper limb.

Key words Hmiplegia, Fnction, Robot therapy, Upper limb, Stroke

Corresponding author Young-Dong Kim(exptkyd@hanmail.net)

Received date 31. December 2015
Revised date 28. January 2016
Accepted date 20. February 2016

I. Introduction

The tissue in cerebral cortex can be damaged partially by stroke and other neurological injuries so that not only sensorimotor areas but also motor programs can be disturbed: a result is an impairment of arm and hand motor function.[1)] A robot can control and quantify the intensity of practice and objectively adjust changes in movement kinematics and forces. In addition, providing novel options for treatment, this technology might give an insight of our understanding of the mechanisms which is important in the recovery of motor function after stroke like neural reorganization and motor learning processes.[2)] The improvement process of upper limb function is often slower than the recovery process of lower limb function. [3)] As a matter of fact, constraint induced or forced-use treatments, in which the partially paralyzed upper extremity is the center of attention of motor activity, have led to main improvements in motor power both in the acute and chronic treatment period after stroke. The employ of robotics in rehabilitation is a comparatively novel approach that transfers scientific concepts to clinical practice for supporting disabled people.[4)] Robot-assisted devices usually have in some degree the following apparatus: power providing system, mechanical system, robot manipulators, actuators, sensors, data processing unit, computer program, control system, and software. To supply arm exercise for patients, an end-effector of robot-assisted device in which the robot controls the manipulators by giving force on the patient's hand is used. In spite of the increasing popularity of robot therapy (RT) for stroke treatment, characteristics of the patients who might get an advantage the most from this treatment stay understudied.[5)] Practices such as initiation movement and controlled reaching to the target with RT would have subjects get better ability adjusting muscle power from the start and controlling sway all the way to the target so that subjects would improve function of upper extremity after the intervention.

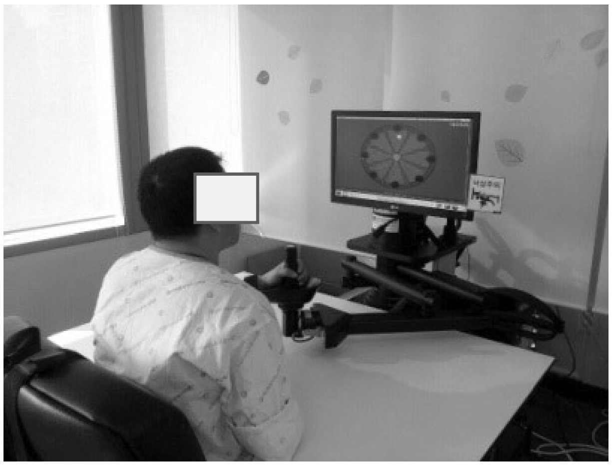

Figure 1. Reaching to a target

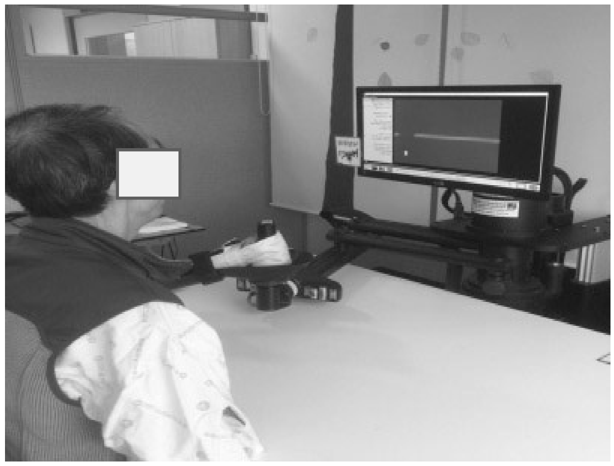

Figure 2. Drawing a line

II. Materials and Methods

The subjects in this study were 3 right hemiplegic patients from Chungnam university hospital in Daejoen. They are all males and the mean age (± standard deviation) is 59.33 (± 15.17) years old. The mean time (± standard deviation) since stroke is 19.33 (± 0.57) months. The inclusion criteria were patients with hemiplegia after a stroke; at least 6 months since onset; able to communicate and must understand the instructions given. All subjects provided written informed consent to take part in the study prior to its initiation. This study followed the principles of the Declaration of Helsinki. Subjects were received Upper Limb Robot Therapy (ULRT, InMotion™) for 30 minutes for each session, 5 times a week for a month from November 3 to 28, 2014. Figure 1 and 2 show how to use this divice. There were five different supports from ULRT such as robot initiation (RI), robot power (RP), motion jerk (MJ), target distance (TD), line distance (LD). RI is the frequency the robot initiates a movement first than a subject. RP is an amount of support from ULRT when moving from the start to the target. MJ is the extent of sway of upper extremity in the movement. TD is the distance a subject moves the hand beyond the target. LD is the extent of deviation from the direct line between the start and the target. And upper limb function was evaluated by InMotion™ with rehabilitation robot program and manual function test (MFT)[6] in pre and post intervention. All data were analyzed using SPSS version 18 (Statistical Package for the Social Science). Wilcoxon signed ranked test was used to determine variations in the group. All data were presented as mean with standard deviation (SD). A α=.05 and 0.1 level of significance was used for all statistical tests.

III. Results

MFT was improved by 2.33 points in the post test and significant differences are shown in RI (by 3.5), RP (by 51.75) and MJ (by 69.25) between pre and post ULRT test. MJ and LD (by 1.58) were increased and RI, RP and TD (by 2.58) were decreased between pre and post ULRT test. Table 1 and Figure 3 show the results.

Table 1. Variations of function between pre and post test

(N=3)

	MFT	RI	RP	MJ	TD	LD
Pre-test	4.00±4.00[a]	3.58±3.44[a]	124.91±49.44[a]	130.08±30.10[a]	3.75±0.90[a]	11.08±2.89[a]
Post-test	6.33±5.85	0.08±0.14*	73.16±19.23*	199.33±43.19*	2.58±0.87	12.66±3.05

*p<0.05, a; mean±SD, SD; Standard Deviation; MFT, Manual Functional Test RI, Robot Initiation; RP, Robot Power; MJ, Motion Jerk; TD, Target Distance; LD, Line Distance

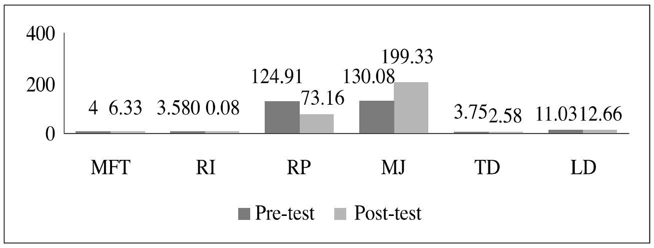

Figure 3. Variations of function between pre and post test

IV. Discussion

RT uses key factors of motor learning for treatment, including greatly intensive, task-specific, reproducible, and interactive performance. Cumulative research proof and systematic reviews support the effectiveness of ULRT for influencing motor and functional outcomes in patients with hemiplegia after a stroke.[7] In this study, first of all, initiation of movement reaching to the target was initiated more by subjects after the intervention significantly. Moreover, the extent of support from the robot when the subjects were reaching out was diminished as well. With those results, we considered that subjects regained ability to recruit proper muscles and relative muscle power in order not only to stabilize shoulder joint but also move the arm straight forward when reaching the upper extremity out to the target. Therefore, the distance passing beyond the target was reduced with controlled movement of the upper limb. However, when the subjects were reaching their arm out, there were more increased perturbations in the affected arm which were shown in the data of MJ and LD. It happened because of a lack of agonist and antagonist coordination of the arm. Even though the subjects became not relying on the support from the robot when initiating movement and during reaching out, they still showed less rhythmical and accurate arm motion. Nonetheless, MFT was improved after ULRT intervention. Even though the extent of improvement in MFT was small but it is important that ULRT gave effectiveness on shoulder and hand function in some degree. In previous study, an augmented therapeutic effect of robot-assisted therapy consisting of repetitive, continuous, functional movements in three-dimensional space was significantly shown in the values of grip power, wolf motor function test, and box and block test in robot-assisted therapy group in comparison with gains in control group and it improved the upper limb function of the patients with stroke. [8] With the results in this study, we found out the ULRT intervention can be one of ways to apply for male-patients with hemiplegia in order to increase not only muscle strength and flexibility but also the upper limb function. Therefore, the further study needs to gather as many subjects as possible to generalize the results statistically.

References

1. Shumway-Cook A, Woollacott MH. Motor control: theory and practical applications. 2nd ed. Philadelphia: Williams & Wilkins; 2001.
2. Fasoli SE, Krebs HI, Stein J, et al. Effects of robotic therapy on motor impairment and recovery in chronic stroke. Arch Phys Med Rehabil. 2003;84(4):477-82.
3. van der Lee JH, Wagenaar RC, Lankhorst GJ, et al. Forced use of the upper extremity in chronic stroke patients results from a single-blind randomized clinical trial. Stroke. 1999;30(11):2369-75.
4. Volpe BT, Krebs HI, Hogan N. Is robot-aided sensorimotor training in stroke rehabilitation a realistic option? Curr Opin Neurol. 2001;14(6):745-52.
5. Hsieh YW, Lin KC, Wu CY, et al. Predicting clinically significant changes in motor and functional outcomes after robot-assisted stroke rehabilitation. Arch Phys Med Rehabil. 2014;95(2):316-21.
6. Michimata A, Kondo T, Suzukamo Y, et al. 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(3):257-67.
7. Mehrholz J, Haedrich A, Platz T, et al. Electromechanical and robot-assisted arm training for improving generic activities of daily living, arm function, and arm muscle strength after stroke. The Cochrane Library. 2012.
8. Yoo DH, Cha YJ, Kim Sk, et al. Effect of three-dimensional robot-assisted therapy on upper limb function of patients with stroke. J Phys Ther Sci. 2013;25(4):407-9.