IOSR Journal of Nursing and Health Science (IOSR-JNHS)
e- ISSN: 2320–1959.p- ISSN: 2320–1940 Volume 7, Issue 3 Ver. VIII (May-June .2018), PP 05-10
www.iosrjournals.org

Effect Of Robot Assisted Training On Hand Function In Stroke Patients.

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Abstract: ***:Background:*** *Robot-assisted therapy is one of the new technologies that used in rehabilitation of stroke patients for improving the process of recovery and enhancing functional activity.* ***Objective:*** *The aim of the current study was to investigate the effect of robotic assisted training on the hand function in stroke patients.* ***Methods:*** *Twenty male patients with stroke were selected from king Fahd hospital in Jeddah participated in this study. The patients were randomly assigned into two equal groups; control group and study group. All patients were assessed for functional performance by manual function test and for pinch and grip strength by hand held dynamometer. Both groups were treated with traditional physical therapy program. Additionally the study group received robotic assisted training. The treatment was given three time per week for eight weeks,.* ***Results:*** *The findings showed a significant increase in the mean values of manual function test, grip and pinch strength after treatment in the study group. For the control group there was a significant increase in the mean values of grip and pinch strength after treatment, but there was non-significant difference in the mean values of the manual function test. Also the results showed significant differences between control and study groups in manual function test and grip strength after treatment.* ***Conclusion:*** *Robotic assisted training, in addition to traditional physical therapy program, is effective in improving functions of the affected hand in stroke patients.*

Key words*: Stroke – Hand function – Robotic training.*

Date of Submission: 02-06-2018 Date of acceptance: 18-06-2018

I. INTRODUCTION

Stroke is the most leading cause of disability and motor dysfunction all over the world. The majority of patients with stroke have impaired arm and hand functions, resulting in limitation of using their arm and hand in daily living activities, and affecting the quality of life[1].

The motor and sensory dysfunctions are the most common impairments of stroke patients. Functional impairment due to stroke has a negative effect on performing different activities of daily living, such as reaching and grasping and manipulative skills. Furthermore, stroke patients often manifested with spasticity of the elbow and hand muscles. Spasticity of upper limb can lead to pain, which has bad impact on rehabilitation outcomes and patient's quality of life[2].

Impairment of the muscle activation coordination in stroke leads to impairment of dexterity. Also, diminished activated motor units number, leads to weakness of the muscles in patients with stroke. Therefore the intensive functional training has been suggested to make cortical activation changes, even in patients with chronic stroke[3].

There are several physical therapy approaches for stroke management. The approaches based on different concepts about motor recovery have been implemented[4]. Clinical research has been applied to use the task oriented approach in the management of neurological disorders. A task-specific approach retraining for upper extremity control seeks to minimize impairments while maximizing the patient's functional performance[5].

Several stroke patients experienced good motor improvement of the proximal part with the upper extremity rehabilitation but they experienced limited recovery of the distal part[6,7]. Rehabilitation for stroke is a difficult process, as the training programs are generally labor-intensive and time-consuming for both therapist and patient. Advanced technologies as robotic devices provide safe and intensive training using repetitive tasks for patients with stroke[8].

Rehabilitation by robotics has more benefits than traditional treatment techniques. Advanced robotic devices are capable of measuring the performance with high reliability and accuracy and to provide consistent training[9]. Furthermore, robots provide more independent training for the patients[10].

The ability to provide intensive training is the main advantage of using robots in rehabilitation program[11]. Rehabilitation for stroke patients with motor dysfunction using robotic training technology is a promising therapy. There is a rapid increase of research into robotic rehabilitation and also the number of robots[12]. So this study was conducted to investigate the effect of robotic assisted training on hand function in stroke patients

II. SUBJECTS, MATERIALS AND METHODS

Participants:

This study was carried out at the physical therapy department of king Fahd general hospital in Jeddah, Saudi Arabia. Twenty male stroke patients were selected from the out-patient clinic of king Fahd general hospital. Inclusion criteria were as follows: Patient's age ranged from 45- 60 years old , the stroke was in the dominant cerebral hemisphere, The duration of illness ranged from 6 months to 2 years, the degree of spasticity in upper limb ranged from 1+ to 3 according to modified Ashowrth scale and patients were able to maintain balance from sitting and standing. Subjects were excluded according to the following criteria: Patients who have cognitive deficits, visual impairment and other medical disorders that might affect hand function (old fractures, surgery, subluxation of the shoulder). Ethical approval was obtained from the local Ethics and research Committee and all participants signed a written informed consent before participation.

Design of the study:

The current study was a randomized controlled trial. Twenty stroke male patients were included in this study. patients were assigned randomly into two groups, group A (control) and group B (study), 10 patients in each group. Randomization was performed by online graphPad program (GraphPad Software, San Diego, California, USA) after assigning a specific number for every subject. For both groups evaluation of proximal arm movements, fine and gross dexterity by Manual Function Test (MFT) as well as grip and pinch strength by hand held dynamometer were done for affected side before and after treatment.

Instrumentations:

Hand held dynamometer:

Jama hand held dynamometer manufactured in U.S.A was used in this study .It has a meter with a scale ranged from 0-90 kilogram or from 0 to 200 pounds. Also it has baseline hydraulic pinch gauge to measure grip and pinch strength.

Armeo Spring system:

Armeo Spring system (Hocoma AG, Switzerland) is an orthosis of the arm, consisting of handgrip with pressure sensors and a spring mechanism which provides weight support adjustment for the affected arm, thus facilitating functional movements of the arm.

Procedures:

Assessment procedures:

Manual function test (MFT)

The Manual Function Test (MFT) was used to assess proximal movements of the arm as well as fine and gross hand function of patients with stroke[13]. The Manual Function Test consists of eight subtests. The scores can range from zero (sever impairment) to thirty two points (complete function). The eight subtests include: arm forward elevation (FE), arm lateral elevation (LE), palm touching the occipit (PO), palm touching the back (PD), grasping (GR), pinching (PI), cubes carrying (CC), and manipulation of pegboard (PP). For each patient three trials were done and the best trial was taken for statistical analysis. Verbal instruction and demonstration were provided by the examiner before testing.

Grip and pinch strength:

Jama hand held dynamometer was used to measure the pinch power. Each patient was seated on standard chair with back supported, feet rested on ground with 90° flexion hip and knee. The subject was asked to hold arm vertically to the side of trunk; with elbow 90° flexion. The patient was asked to grasp the dynamometer with the fixed handle between the palmer gutter and the thumb of examined hand and the other adjustable handle of the dynamometer for grip strength measure. For pinch strength the patient was asked to pinch between thumb and lateral aspect of index by using pinch measure piece of the dynamometer. The subject was asked to relax. Three trials were given with one minute rest after each trial, and the mean of the three trials were recorded.

Treatment procedures:

Patients of the study and the control groups received their treatment program three times per week, for eight successive weeks. Both groups received the traditional physical therapy program for 30 minutes per session; in the form of prolonged stretch, active upper extremity exercises, weight bearing over the affected arm with elbow extended, reaching forward and sideward, and hand function training including the following activities: turning cards, transfer cubes, grasping rubber ball, picking up coins and pegboard tasks ,While the study group received robotic assisted training in addition to the traditional physical therapy program.

The robotic system Armeo Spring system (Hocoma AG, Switzerland) was used for the training of the arm and hand in the study group. The device offers augmented performance feedback for patient motivation. The robotic arm exoskeleton automatically adapts to the patients' capabilities and provides assistance when needed. Different levels of gravity support through the spring mechanism were provided by the mechanical adjustment of the arm, which allows patients to use residual function of the affected upper limb, so the patient can perform a larger active range of motion within a 3D workspace. The pressure-sensitive handgrip integration also provides the performance of graded exercises of grasp and release, through position sensors and software, therefore the robotic device can be involved in functional training of the tasks that are simulated on a computer screen as a virtual learning environment, which provide a visual and auditory feedback during and after the task.

The setup of robotic device was performed before training including establishment of compensation of weight, maximal workspace, and level of difficulty of the exercise. The amount of gravity support provided by the robotic device was determined based on the patient's ability to keep the affected arm in a position of shoulder flexion 45° and elbow flexion 90°. Training frequency was three times per week for eight successive weeks. The session lasted 30 minutes and included repetitive and intense performance of five virtual reality tasks, five minutes for each task, included, **Egg Cracking:** The Patient grasped eggs from the bowl and put them into the frying pan by moving in the frontal plane, **Jump:** The patient had to make the dog jump over the mushrooms and thereby collect the precious stones by pressing the handgrip, **Fruit shopping:** The patient grasped the big red apple and put it into the shopping cart by moving in the frontal plane, **Shelf:** The patient grasped the objects lying in the shelf and put them into the basket in the middle of the room**, Letter box:** The patient must grab a letter from the pile and throw it into the mailbox. If the patient finds the correct position on the mailbox the lid opens

Statistical Analysis:

The statistical package for social sciences (SPSS) computer program (version 20, SPSS, Inc, Chicago, IL,USA) was used for data processing, using the p– value < 0.05 as acute-off level of significance. Data were statistically analyzed using: The arithmetic mean and the standard deviation, Dependant t- test was used to compare between means in the subject's parameters within groups. Independent t-test was used to compare between means in the subject's parameters between the two groups.

III. RESULTS

The aim of study was to investigate the effect of robotic assisted training on hand functions in stroke patients. Manual function test, hand grip strength and pinch grasp strength were evaluated for control and study groups before and after intervention.

General characteristics of the patients:

The mean value of age in the control group was 55.6±4.22 and their mean duration of illness was 11.3±1.88 months. The mean value of age the study group was 56.00±3.43 and their mean duration was 10.7±2.1 months. The results revealed non-significant difference in the mean values of age and duration of illness between both groups p =(0.81) and (0.51) respectively, as shown in Table (1) and Fig. (1).

Table (1): The mean values of the age of the patients and the duration of illness in control and study groups.

Item	(Group A) Control	(Group B) Study	*t*	*P*
	mean ±SD	mean ±SD		
Age (years)	55.6±4.22	56.00±3.43	-0.23	0.81
Duration (Months)	11.3±1.88	10.7±2.11	0.67	0.51

** Significant at ≤ 0.05, SD: standard deviation.*

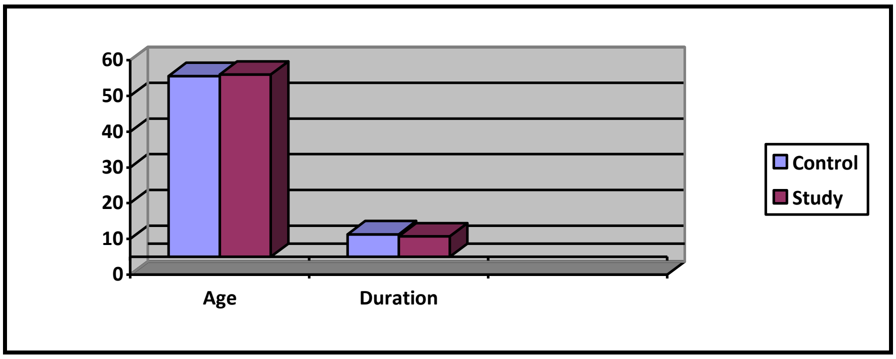

Fig. (1): The mean values of the age of the patients and the duration of illness in control and study group.

Manual function test (MFT):

The results showed a non significant difference in MFT mean values before and after treatment in control group (p = 0.08). In contrast, the study group showed significant increase in MFT mean values (p = 0.0001). The results showed a non significant difference between control and study groups regarding MFT before treatment (p = 0.46), while the results showed a significant difference after treatment (p= 0.03) as shown in Table (2) and illustrated in Fig (2).

Table (2): Comparison between control and study groups mean values of MFT before and after treatment.

MFT	**(Group A) Control**	**(Group B) Study**	***t***	**P**
	mean ±SD	**mean ±SD**		
Pre	18.3± 2.4	17. 4± 2.98	0.74	0.46
Post	18.6±2.71	21.6±3.23	-2.24	0. 03*
T	-1.96	-7.58		
P	0.08	0.0001 *		

** Significant at ≤ 0.05, SD: standard deviation.*

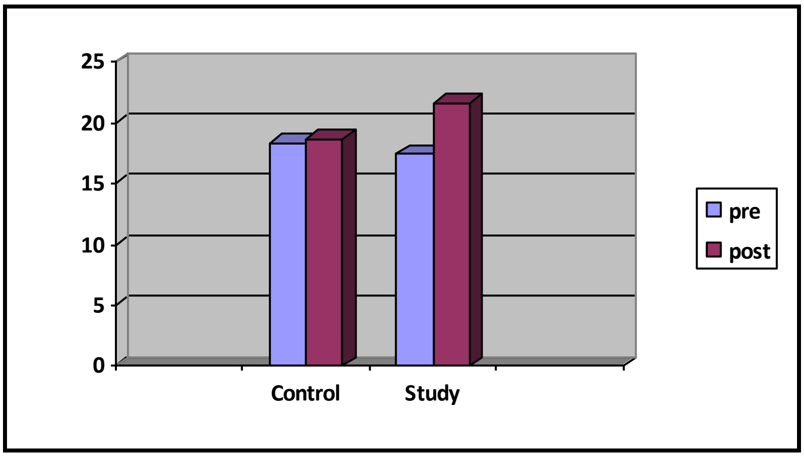

Fig. (2) Mean values of manual function test before and after treatment in control and study group.

Hand grip strength:

The results revealed a significant difference in hand grip strength mean values before and after treatment in control group (p = 0.01), also the study group showed high significant increase in hand grip strength mean values (p = 0.0001). The results showed a non significant difference between control and study groups before treatment (p = 0.27), in contrast the results showed a significant difference after treatment between both groups (p = 0.03), as shown in Table (3) and Fig. (3).

Table (3): Comparison between control and study groups mean values of hand grip strength before and after treatment.

Hand grip strength (kilogram)	**(Group A) Control**	**(Group B) Study**	*t*	P
	mean ±SD	mean ±SD		
Pre	8.80±1.87	7.50±3.13	1.12	0.27
Post	9.3±2.002	11.8±2.85	-2.26	0.03*
T	-3	-14.3		
P	0.01*	0.0001*		

** Significant at ≤ 0.05, SD: standard deviation.*

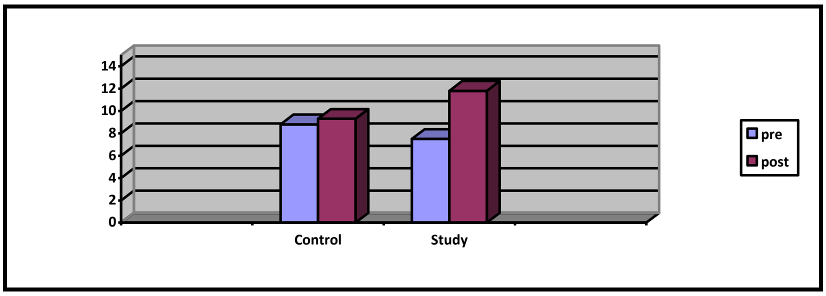

Fig. (3): Mean values of hand grip strength before and after treatment in control and study group.

Pinch grasp strength:

The results revealed a significant difference in pinch grasp strength mean values before and after treatment in control group (p = 0.04). Also, the study group showed a high significant difference in pinch grasp strength mean values (p = 0.0001). The results showed a non significant difference between control and study groups regarding pinch grasp strength before and after treatment (p = 0.66) and (p= 0.06) respectively, as shown in Table (4) and Fig. (4).

Table (4): Comparison between control and study groups mean values of pinch grasp strength before and after treatment.

pinch grasp strength (kilogram)	(Group A) Control	(Group B) Study	*t*	P
	Mean ±SD	**mean ±SD**		
Pre	3.5±1.58	3.8±1.47	-.43	0.66
Post	3.9±1.9	5.50±1.77	-1.93	0.06
T	-2.44	-6.53		
P	0.04*	0.0001*		

* *Significant at ≤ 0.05, SD: standard deviation.*

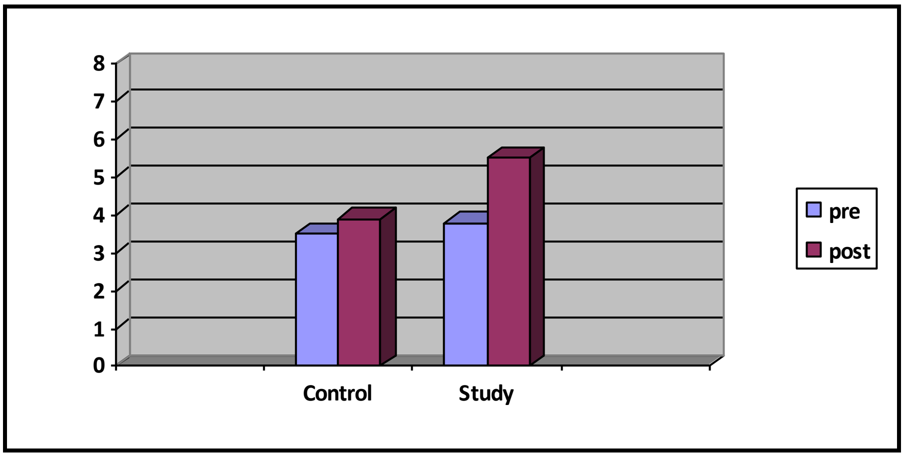

Figure (4): Mean values of pinch grasp strength before and after treatment in control and study groups.

IV. DISCUSSION

This study was conducted to evaluate the effect of robot assisted training on function of the hand in stroke patients. twenty patients were randomly classified into two equal groups: Control group that received traditional physical therapy program and study group that received the robotic assisted training in addition to the same traditional physical therapy program.

The results revealed significant increase in the functional performance evaluated by manual function test and significant improvement in grip and pinch strength in the study group after treatment. This improvement could be explained by multi-joint repetitive and intensive training of function which is provided by task-oriented robot supported movement. The results of this study is consistent with the findings of **Masiero, et al.,** [14] who found significant improvement after robot based training in functional outcomes of the affected upper limb. They suggested that robotic exercises enhance the function of the upper limb through intensive practice of specific task.

This is also consistent with **Takahashi et al**.,[15] who reported that practicing hand movements by assistance of robot may improve the hand function of stroke patients. Also this come in agreement **Hwang et al.,**[16] who found significant hand function improvement in patients with both sub acute and chronic stroke after using novel robot.

The improvement also could be attributed to the strong afferent sensory inputs that provided by robotic rehabilitation and arrive sensory area of the cortex, this explanation come in agreement with **Kording et al .,**[17] who stated that the elicited sensory inputs by assistive forces promote the appropriate associations between sensory and motor areas of the cortex. **Kaelin-Lang el al.,**[18] stated that the excitability of the motor cortex could be influenced by afferent sensory stimuli.

Furthermore **Hayashi et al.,**[19] stated that the repeated performance of intensive robot assistive exercises may results in structural changes of the cortex. **Oujamaa et al.,**[20] suggested that the virtual reality is able to provide a real object in a contextual manner, which enhance the attentive and visual feedback. Another explanation is the improvement of the proximal control around shoulder and elbow which may improve the distal function, this is consistent with the findings of previous studies that found improvement of proximal arm function[21,10]. This also come in agreement with **Kahn et al.,**[22] who found that robotic assisted training for reaching improved arm movement ability.

The improvement in the grip and pinch strength in study group is consistent with findings of **Butefisch et al.,**[23] who stated that this specific training increase the discharge rate of pyramidal tract to increase the number of motor units available for recruitment and increase the force exerted during movements. On the other hand, the control group showed improvement in both grip and pinch strength after treatment and this could be attributed to the effect of exercise training, but in comparing the mean values between both groups after treatment, the study group showed significant improvement in both manual function test and grip strength.

V. CONCLUSION

The present study concluded that the use of robot assisted training had a positive effect on improving hand function in stroke patients combined with the traditional rehabilitation program as an additional therapeutic intervention.

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