EFFECT OF ROBOT-ASSISTED THERAPY ON UPPER EXTREMITY FUNCTION IN CHRONIC STROKE PATIENTS

Tarek M Youssef 1, Gehan M Ahmed2, Hanan A Amer3, Hanan Hosny M Batticeha4, Abdelhamied Ibrahim ELSayed Mohammad Elsherbin5

1 Assistant lecturer of physical therapy, Department of physical therapy for Neuromuscular disorder and its surgery, Beni-Suef university, Egypt
2 Professor of physical therapy, Department of Physical therapy for neuromuscular disorder and its surgery, Cairo university, Egypt
3 Professor of neurology, Faculty of medicine, Cairo university, Egypt
4 Lecturer of physical therapy, Department of Physical therapy for neuromuscular disorder and its surgery, Faculty of physical therapy, Modern university for technology and information, Egypt
5 Ass prof. of physical therapy, Department of occupational therapy, National institute of longevity elderly sciences NILES Beni-Suef University, Egypt

ABSTRACT

Purpose of the study: This preliminary study was aimed to compare the effect of advanced robotic-assisted therapy device on upper extremity function in early and late chronic stroke patients.

Methods: 45 chronic male stroke patients were divided into three equal groups (A, B and C). Each group received the same designed physical therapy program for upper extremity in addition to robotic therapy for both groups A (from six to two years after stroke) and B (more than two years after stroke) 12 sessions of robotic treatment for four weeks in a row (3 days/week). The Amadeo robotic system (Tyromotion GmbH Graz, Austria) was used to provide the treatment. Each patient was assessed before and after four weeks of intervention protocol by Fugl-Meyer Scale (FM) test to evaluate sensorimotor function of upper limb and by Amadeo robotic system to evaluate grip strength.

Results: There was statistically significant post-treatment improvement in Fugl-Meyer score and grip strength in all groups. The percentage of improvement was higher in group A compared to other groups.

Conclusion: Adding robotic assisted therapy to designed physical therapy program for upper extremity rehabilitation in chronic stroke patients improves grip strength and upper limb motor recovery especially as early as possible in chronic stage

Keywords: Amadeo robotic system, robotic assisted therapy, stroke; hand function, stroke rehabilitation

I. INTRODUCTION

Stroke is the most common cause of physical impairment in adults. Although the majority of stroke patients regain independent movement, many do not regain functional upper limb use (1). In 30 percent to 66 percent of hemiplegic stroke patients, deficiencies in upper limb ability continue six months after the stroke. In fact, one of the most prevalent motor impairments is finger extension. The grabbing and holding of items is a routine task that remain impaired(2). Anxiety levels are higher in people who have problems with their upper limbs and a lower subjective health-related quality of life one year after a stroke. As a result, increasing upper-limb abilities is a significant rehabilitation goal in stroke recovery (3).

For decades, the stroke rehabilitation community assumed that the time window for providing therapy was limited to the first three months after a stroke. Neuromuscular adaptation to a systematic outpatient exercise regimen is one of the contributing causes to the post stroke healing plateau. (4). Rather than discontinuing therapy when
neuromuscular adaptation occurs, a range of alternate or creative approaches to therapy could be applied to aid recovery and overcome the adaptive state. (5).

In chronic stroke patients, efficient upper-limb motor recovery is critical. The science of neurorehabilitation and neuro-engineering technologies is becoming increasingly interested in severe hand function impairment following a stroke (6). Robot-assisted therapy is an unique and fast increasing technology for boosting the recovery and facilitating function restoration after a stroke Robotic systems that are advanced and sophisticated are capable of providing constant training and measuring performance with high accuracy and reliability (7).

Robot-assisted rehabilitation is basically centered on the concepts of motor re-education, which is performed through separate sensory-motor and task-oriented activities. In this context, the learning process refers to the re-acquisition of motor abilities following various forms of central nervous system (CNS) damage (8). Because the process of motor learning is aided when there are external stimuli, the main role is played not by the movement itself, but by focusing on the objective of its implementation. Robotic-assisted therapies enable for two to seven times more mobility than traditional therapies. It's also important psychologically since therapy reinforces effective movement sequences with positive reinforcement (9).

Robots can help to intensify therapy by enhancing stimuli and establishing circumstances for intensive active training, aided, and passive exercises. Robots' actions are mostly dependent on the use of aided workouts, which allow the patient to complete the activity that has been begun (10).

II. METHODS

Study design

This was a randomised controlled clinical trial conducted at Cairo University's Faculty of Physical Therapy. The study was approved by the faculty of physical therapy at Cairo University's local ethics committee (NO:P.T.REC/012/001664). Patients were informed about the study's goals and procedures, and written consent was obtained before to participation.

Subjects

45 chronic male stroke patients were classified into three groups of equal size (A, B and C). For the duration of the study, each group got the same physical therapy program for upper extremity in addition to robotic therapy for both groups A (from six to two years after stroke) and B (more than two years after stroke) 12 sessions of robotic treatment for four weeks in a row (3 days/week). The Amadeo robotic system (Tyromotion GmbH Graz, Austria) was used to provide the treatment. Before and after four weeks, each patient was evaluated after intervention protocol by Fugl-Meyer Scale (FM) test to evaluate sensorimotor function of upper limb and by Amadeo robotic system to evaluate grip strength.

Inclusion criteria:

- Patient with cva due to ischaemic stroke in the domain of the carotid system
- Patients age ranged from 50 to 65 years
- Duration of illness not less than 6 months
- Spasticity of upper limb ranged from (1:1+) according to thr Modified Ashworth scale
- Degree of weakness in paretic upper limb was not less than grade 2 on manual muscle testing scale
- Full passive range of motion of wrist and fingers
- Mini mental state score > 21 can understand simple verbal instructions

Exclusion criteria:

- Contractures or limitations in range of motions of wrist joints and metacarpophalangeal joints and interphalangeal joints
- Spasticity of upper limb more than 1+
- Comorbidities affect upper limb function (eg. osteoarthritis, previous hand surgeries..etc) and pre-existing musculoskeletal disease significantly
- Duration of illness less than six months
Procedures
Outcomes measurements were collected for all participant before the study and 1 month after the intervention protocol

III. INSTRUMENTATION FOR EVALUATION

The upper limb Fugl-Meyer test (FM)
The FM test evaluates the upper limb's sensory-motor function. The muscle reflex evaluation of the forearm biceps and triceps muscles, synergy of flexion and extension of the entire limb, and movements with and without muscle synergy are all included in this scale. The test evaluates the wrist and hand's functionality, including finger flexion and extension, as well as individual gripping actions in the upper limb's proximal region. The speed and coordination of movement are assessed. A maximum of 66 points is attainable (11).

Instrumentation for assessment and treatment
The Amadeo robot AMADEO is a robot manufactured by Tyromotion GmbH Graz, Austria. It was used to assess grip strength and to provide properly selected training combined with a high frequency of repetitive exercises targeted fingers. This device offers a position-controlled active-assisted exercise mode as well as isometric modes with visual feedback during computerised games that emphasise flexion and extension of fingers. (12).

Following a baseline examination, individuals got 1 hour of therapy with the device three times per week for four weeks (a total of 12 sessions). The arm was strapped into an adjustable stabilising splint attached to the robotic device with the wrist in an approximately neutral position, the forearm pronated, and the subjects were sat in a comfortable position. Training by Amadeo provided in three different modes continuous passive motion therapy, assistive therapy and Active gaming which entails active training in a virtual reality environment. (13).

Selected physical therapy program
Each group got the same designed physical therapy program for upper extremity include:

Shoulder flexors, elbow extensors, and wrist extensors are the muscles in the upper body that need to be strengthened. Stretching exercises (shoulder adductors, elbow flexors and wrist flexors) Weight bearing on the affected side: the patient sit and tried to bear weight on the affected upper limb for ten seconds and then relax. The exercise repeated from five to ten times according ability of each patient (14).

IV. DATA ANALYSIS

For comparing subject characteristics between groups, descriptive statistics and the ANOVA test were used. The Shapiro-Wilk test was used to ensure that the data had a normal distribution. To determine group homogeneity, Levene's test for homogeneity of variances was used. Mixed-media design MANOVA was used to compare effects within and between groups. For future multiple comparisons, post-hoc testing using the Bonferroni correction were used. For all statistical tests, the significance level was set at \( p > 0.05 \). The statistical programme for social studies (SPSS) version 25 for Windows was used for all statistical analysis (IBM SPSS, Chicago, IL, USA).

V. RESULTS

Subject characteristics:
Table (1) showed the subject characteristics of the group A, B and C. There was no significant difference between groups in the subject characteristics \( (p > 0.05) \).

Table 1. Basic characteristics of participants.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Group A Mean ± SD</th>
<th>Group B Mean ± SD</th>
<th>Group C Mean ± SD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>57.26 ± 4.66</td>
<td>58.66 ± 4.65</td>
<td>57.06 ± 3.75</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>85.6 ± 2.37</td>
<td>86.2 ± 2.78</td>
<td>87.13 ± 2.69</td>
<td>0.28</td>
<td></td>
</tr>
</tbody>
</table>
Effect of treatment on grip strength and Fugl-Meyer Scale (FM):

A significant interaction of treatment and time was detected using mixed MANOVA (F = 32.15, p = 0.001). There was a significant main effect of time (F = 593.23, p = 0.001). There was a significant main effect of treatment (F = 5.99, p = 0.001). Table 2 showed descriptive statistics of grip strength and FM and the significant level of comparison between groups as well as significant level of comparison between pre and post treatment in each group.

Within group comparison:

There was a significant increase in grip strength in flexion and extension and FM of the three groups post treatment compared with that pre treatment (p < 0.001). The percent of change of grip strength of flexion and extension and FM in group A was 21.01, 73.63 and 19.61% respectively while that in group B was 10, 41.81 and 9.89% respectively and that in group C was 5.15, 21.03 and 6.32% respectively. (table 2).

Between groups comparison:

There was no significant difference in all parameters between groups pre-treatment (p > 0.05). There was a significant increase in grip strength flexion and extension and FM of group A compared with that of group B (p < 0.05) and group C (p < 0.001) post treatment (p < 0.001). There was a significant increase in grip strength flexion and extension and FM of group B compared with that of group C (p < 0.01) (table 2).

Table 2. Mean grip strength and FM pre and post treatment of group A, B and C:

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grip strength, extension</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N)</td>
<td>mean ± SD</td>
<td>mean ± SD</td>
<td>mean ± SD</td>
<td>A vs B</td>
</tr>
<tr>
<td>Pre treatment</td>
<td>41.26 ± 3.08</td>
<td>42.73 ± 2.37</td>
<td>41.14 ± 2.52</td>
<td>0.42</td>
</tr>
<tr>
<td>Post treatment</td>
<td>49.93 ± 3.59</td>
<td>47 ± 1.96</td>
<td>43.26 ± 2.84</td>
<td>0.02</td>
</tr>
<tr>
<td>MD (95% CI)</td>
<td>-8.67 (-9.31:-8.02)</td>
<td>-4.27 (-4.91:-3.62)</td>
<td>-2.12 (-2.76:-1.47)</td>
<td></td>
</tr>
<tr>
<td>% of change</td>
<td>21.01</td>
<td>10</td>
<td>5.15</td>
<td>p = 0.001</td>
</tr>
<tr>
<td>Grip strength, flexion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N)</td>
<td>mean ± SD</td>
<td>mean ± SD</td>
<td>mean ± SD</td>
<td>A vs B</td>
</tr>
<tr>
<td>Pre treatment</td>
<td>9.33 ± 1.67</td>
<td>9.4 ± 1.12</td>
<td>8.56 ± 1.29</td>
<td>1</td>
</tr>
<tr>
<td>Post treatment</td>
<td>16.2 ± 2.14</td>
<td>13.33 ± 1.39</td>
<td>10.36 ± 1.9</td>
<td>0.001</td>
</tr>
<tr>
<td>MD (95% CI)</td>
<td>-6.87 (-7.52:-6.21)</td>
<td>-3.93 (-4.58:-3.27)</td>
<td>-1.8 (-2.45:-1.14)</td>
<td></td>
</tr>
<tr>
<td>% of change</td>
<td>73.63</td>
<td>41.81</td>
<td>21.03</td>
<td>p = 0.001</td>
</tr>
<tr>
<td>FM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre treatment</td>
<td>41.8 ± 2.48</td>
<td>42.46 ± 2.26</td>
<td>41.13 ± 2.32</td>
<td>1</td>
</tr>
<tr>
<td>Post treatment</td>
<td>49.13 ± 2.67</td>
<td>46.66 ± 2.25</td>
<td>43.73 ± 2.68</td>
<td>0.03</td>
</tr>
<tr>
<td>MD (95% CI)</td>
<td>-7.33 (-7.89:-6.76)</td>
<td>-4.2 (-4.76:-3.63)</td>
<td>-2.6 (-3.16:-2.03)</td>
<td></td>
</tr>
<tr>
<td>% of change</td>
<td>19.61</td>
<td>9.89</td>
<td>6.32</td>
<td>p = 0.001</td>
</tr>
</tbody>
</table>

SD, Standard deviation; MD, Mean difference; p-value, Level of significance
VI. DISCUSSION

This preliminary study was aimed to assess the effects of a robotic-assisted therapy program in addition to conventional rehabilitation therapy on upper extremity function in chronic stroke patients. Three equal groups of patients were formed (A, B and C). Each group got the same upper extremity physical therapy program in addition to robotic therapy for both groups A (from six to two years after stroke) and B (more than two years after stroke).

Data analysis revealed significant improvement in Fugl-Meyer score and grip strength in all groups. When compared to the other groups, group A had a larger proportion of improvement.

The extent to which motor function has improved observed in other research of chronic hemiparetic people getting comparable doses of robot-assisted motor retraining utilising devices that target more proximal muscles, the results were comparable, as well as other training techniques. The finding that training one part of the upper limb (in this case, the hand) improves motor impairment in other parts of the upper limb (in this case, the shoulder/elbow portion of UEFM) is consistent with previous research that has found similar generalisation of training benefits beyond the segment or segments trained (15).

At this moment, the processes driving this condition remain unknown. One possibility is that increased use of the entire limb as a result of focal training and improved motor control leads to more generalised activation of the sensorimotor cortex, which facilitates plasticity of the cortex controlling other portions of the limb (16).

The increase in grip strength in agreement to Roland et al., (2019) who reported that In the first year after a stroke, grip strength improved dramatically (17).

Numerous studies have highlighted the significance of brain plasticity and its therapeutic potential in neurological illnesses. The use of early, vigorous, repetitive, and context-related exercise as ideal strategies to improve motor relearning and minimise motor deficits is endorsed by accredited theories of cortical remodelling following brain damage. Currently, the paradigm of stroke rehabilitation treatments is based on high-intensity, repetitive repetition, and task-specific training to enhance motor function (18).

The effectiveness of robot-assisted arm training in improving stroke patients' ADL independence and arm function was studied by Mehrholz and colleagues(19), the results showed that a robotic device for the upper limb was generally safe, with minimal adverse effects, and improved arm function and motor strength.

The lesion to the brain tissue that permits sensory-motor connection to alternate between cortical areas causes whole or partial inability to selectively activate muscles, which restricts certain movements. As a result, therapy should begin early and be distinguished by a unique approach to each patient. The most important factors affecting faster patient recovery are intensity, duration and repetition (19).

The new findings add to a growing body of evidence that suggests using targeted, repetitive movement therapy may help people regain motor abilities after a stroke. However, the processes behind the observed improvements in motor function are unknown. The fact that we were able to repair persistent motor impairments after a stroke suggests a link between motor recovery and motor learning, in the sense that the response to therapy was punctuated (20).

These findings of normal motor learning and stroke recovery have supported our assumption that there are "windows of opportunity" after a stroke (corresponding to periods of change between plateaus) in which motor performance can be improved. The fact that patients with consistently stable motor impairments can benefit from targeted and repetitive movement treatment shows that therapeutic intervention is not limited to the acute phase of recovery. At the time of admission to the present study, we can infer that persons with stroke were at or near a plateau in their ability to move the affected arm (21). Our results showed improvement on upper limb functions and grip strength when adding robot assisted therapy to a designed physical therapy program and suggesting that a period of substantial change can follow a plateau in motor performance after stroke. Furthermore, this information backs up the idea that motor recovery takes longer than the first 6 to 12 months after a stroke (22).

Acknowledgements: All participants are should be thanked by the writers.
REFERENCES


