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Research article

BILATERAL OBJECT EXPLORATION TRAINING TO IMPROVE THE HAND FUNCTION IN STROKE SUBJECTS

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ABSTRACT

Recovery of upper extremity sensory and motor function is still one of the complicated and an under achieved task in rehabilitation of the stroke subjects. We believed that object exploration training could play a role in improving the sensory function that helps to improve the motor and overall functions of the hand in stroke subjects. This study attempts to establish the efficacy of Bilateral Object Exploration Training on improving the hand function in stroke subjects. The study design is an experimental study design. Outcome measures are Wolf motor function test score, Moberg pick up test score, 3-D common object identification test score. A total of 60 stroke subjects were selected using random sampling and were allocated into three groups with 20 in each group (Experimental Group-Bilateral object exploration training, Control Group 1-Unilateral object exploration training, Control Group 2 -Conventional Stroke therapy), the mean age(S.D) of the subjects was 54.4(±10.3) . The groups were respectively treated for six weeks with bilateral object exploration training, unilateral object exploration training, and Conventional Stroke therapy, each subjects were trained for 60 min for 4 days in a week for a total of 24 training sessions after which the post measure were recorded. The mean value of bilateral object exploration training group (between pre and post test scores of WMFT 58.25, 53.25 (in seconds), Moberg pick up test scores58.70, 55.95 (in seconds), 3-D Common object identification test scores 59.25, 56.30 (in seconds)) shows significant difference in improvement than unilateral object exploration training group and conventional stroke therapy group. Paired t test and ANOVA was used to analyze the research data, the results showed that the values of bilateral object exploration training group shows significant difference than control group 1 and control group 2, ANOVAs shows significance level ($p<0.001$).Bilateral object exploration training proves to provide tactile experience, improve explorative skills and there by enhance performance of motor task.

Key words: Object exploration training, Stroke, Hand function, 3D common object identification test, Stereo gnosis.

INTRODUCTION

Stroke is one among the leading causes of disability and death globally. According to World Health Organization (WHO) about 15 million people suffer stroke worldwide each year. Of these, 5 million die and more than 5 million are permanently disabled. The increase in incidence rate and decline in mortality rate imposed by modern medicines has eventually resulted in an increased number of stroke survivors with residual neurological deficits and persistently impaired function , especially the recovery of upper extremity sensori motor functions as for a long time been a challenging task in stroke rehabilitation. Recent statistical evidences suggest only about 15 % of those suffering from stroke recover more than 50 % of hand functions and a proportion of less than 3% of adult stroke subject regain more than 70 % of their hand functions.

The process of Object exploration involves a combination of somatosensory perception of patterns on the skin surface and proprioception of hand position and conformation.[1] People can rapidly and accurately identify three-dimensional objects by touch.[2, 3] They do so through the use of exploratory procedures, such as moving the fingers over the outer surface of the object or holding the entire object in the hand.[4] Sensory input is essential for fine manual dexterity and a lack of sensory input causes delayed learning of new motor tasks, clumsiness, lack of precision, and can result in an unused extremity [5, 6]. Although visual information can guide the hand in space and prepare it to grasp, tactile input regulates the force of the grasp provides the control to avoid slippage of objects, and guides the manipulation of an object within the hand disturbed sensibility can influence the manual performance and assessing tactile sensibility can provide an understanding of one attribute that might lead to difficulties in task performance and give guidance for treatment [7].

Varying sensory input patterns created as people move their hands over an object during perceptual exploration and manipulation tell us about its properties-for example its smooth, hard, cold, shape and weighs with the help of information processing perceptual system that uses inputs from receptors embedded in skin, tendon muscles and joints which forms the bases of object recognition judgments. For a long time hand rehabilitation of stroke subjects has only offered less consideration to object exploration training, hence this study attempts to identify the role of unaffected hand in facilitating learning in affected one using alternative designed treatment protocol which consist of a set of objects with highlighted features like textures, shape, size and weighs to improve hand function in adult stroke subjects, which would definitely rejuvenate the spastic hand rehabilitation programs in future. So, tactile object recognition can be viewed as complex information processing that evolves from modality-specific perception of different classes of object features into recognition of object explored.

MATERIAL AND METHODS

Participants: Sixty adults aged from 40 to 65 years (both sex) with middle cerebral artery involved stroke and without any major musculoskeletal injury volunteered to participate and after obtaining informed consent the subjects were recruited from various neurological centers around Chennai, India. All subjects were in chronic stage, having suffered stroke 10 to 39 months prior to the experiment. Exclusion criterion were bilateral impairment, severe deformities of hand, aphasia, cognitive impairs, other severe medical problems. After obtaining consent form according to our institutional ethical committee guidelines, the subjects were randomly assigned to one of the three groups: experimental group (n=20) that received bilateral object exploration training or control group 1 that received unilateral (affected hand) object exploration training or control group 2 that received conventional stroke therapy. Proposal of study was presented to Institutional ethical review committee of Madha Medical College & Hospital, Chennai and approval obtained.

Materials: The training tool consists of objects of different perceptual dimension with a highlighted property: textures, shape, size and weighs, cock up splint. The moberg's pick up test consist of a square plastic box, with dimension 5x5x1cm. The object set includes 12 small common objects that fit within the box, including screw, nail, and paper clip. Safety pin, coin (diameter 1.0 cm), small button (diameter 0.7cm), nut shaft diameter 0.8 cm), padlock key, washer, spike, large button (diameter 2.0cm) and a coin with central circular hole (diameter 2.0 cm, hole diameter 0.5cm).3-D common object identification task consist of a set of 30 objects with high diagnostic property on the basis of Ledermen and Klatzky study. The diagnostic properties include size, form, temperature, texture, weight and hardness.

Training: The training consist of 60 min per day of object exploration training for 4 days a week for 6 weeks- 24 training sessions for the experimental (bilateral hand) and control group 1(affected hand alone). Subjects were seated in a chair and the vision of the objects placed in a table in front of them was blocked during exploration and visual guidance, verbal cues, and explorative guidance were provided when needed. As to size, the objects were deliberately chosen to allow convenient tactile exploration. The subjects with improper hand presentation were given cock up splints [8] to the affected side during training sessions to improve contact area of the hand. In later stages the subjects were informed to touch, hold and identify the objects without the help of examiner Klatzky exploratory procedures (skills) like lateral motion, pressure, static contact, unsupported holding, enclosure and slow contour tracking were taught, demonstrated and trained to improve exploration compatibility and subsequently the patients were required to explain about texture, shape, hardness, weigh of the objects to the examiner during the course of the exploration task[9]. Importantly at most care was taken to place objects with different hardness, shapes, weigh and sizes in same similarity pile and objects that were not correctly identified tactually were presented again to the subjects. Several exploration trials were given to improve identification and to reduce response time. For control group 1 the subjects were informed to use only the affected hand to touch and hold the object for identification with the guidance of examiner in the form of visual exploration, verbal cues, and explorative guidance when needed. For subjects of control group 2 Conventional exercises approaches like (ROM exercises, functional training), activities to retrain upper extremity postural support, weight bearing activities involving upper limb and lower limb, peg board task, stretch, Neuro-developmental treatment, rolling, supine -to sit and sit- to supine, sitting bridging, sit- to- stand and sit- down- transfers, standing ,modified plantigrade, standing, transfers, bilateral arm training with auditory cueing, constraint induced movement therapy.

Testing: The pretest and posttest consist of Wolf motor function test [10], which was selected for its high reliability in measuring functional ability in a variety of functional activities and also appears to be more sensitive than other upper extremity tools[5] this scale appears to test the speed of performance (timed items) through the ability to lift a weight assesses functional strength and quality of motor functions. The Moberg pick up test [11] was used to evaluate fine dexterity functions of hand, it was performed using single hand and the order in which the object were presented with in each block was also randomized and the response time (secs) was the dependent variable. As each object was lifted up, the subject was required to name it.

In 3-D 30 common object identification tests[12, 13, 14] were done with the subjects sitting in front of a table, a board eliminating visual input of object identity and 15 secs of exploration time with 5 secs of pause then the subjects were requested to answer questions about the object placed in their hand after due exploration. The objects were presented in random orders, response time (secs) were measured and a binary response (Yes or No) was noted. Throughout the experiment the rights of the subjects were protected.

List of objects used in 3-D 30 common object identification tests: Flask, Spoon, Towel, Paper clip, Tooth paste tube, Coffee bottle, News paper, Wrist watch, book, Sharpener, Spaghetti, Plush towel, Wood pegs, Paper table cloth, Hard cover book, Dry dough's, Pencil Eraser, Match box, Shirt Button, Hotel soap, Can, Sun flower seed, Dessert fork, Fine sand paper, Metallic clip, Metallic pencil, House key, Metallic glasses, Wooden table, Board with hole.

Fig.1: Training materials

Fig.2: Object exploration training

DATA ANALYSIS AND RESULTS

The investigation of data's from dependent variables WMFT, Moberg pick up test and 3-D Common object identification test of 60 sampled subjects were analyzed by employing suitable statistical techniques such as descriptive, interferential paired ''t'' test and one way ANOVA performed on the mean response time(in seconds). The data's were carefully assessed and recorded with precise accuracy. In experimental group descriptive statistics shows that in WMFT the observed mean 55.55 with standard deviation 4.045 of WMFT before training is decreased to the mean of 45.85 with standard deviation of 3.117 after training the percentage as decreased in 48.5% and in Moberg pick up test the mean 58.15 with Std.Dev 4.705 before the training as decreased to the mean of 50.00 with standard deviation of 3.387 after the training the percentage is decreased in 40.75 %. The more specific outcome measure the 3-D common object identification test recorded a pre and post mean of 57.15 &43.05 respectively with S.D of 7.02-4.51imparting a time decrease of 70.5%. Both control group1 and control group2 showed reasonable decrease in time between pre and post test in all the outcomes, interestingly control group 2(Pre test- WMFT:58.25, Moberg: 58.70, 3D object test:59.25.Post test- WMFT: 53.25, , Moberg: 55.95, , 3D object test: 56.30) exhibited a marginally better outcome than control group 1(Pre test- WMFT:57.05, Moberg: 57.70, 3D object test:57.60.Post test- WMFT: 53.70, , Moberg: 54.10, , 3D object test: 53.45) i.e. subject those received object exploration training with only the affected side had minimal prognosis in motor and tactile skills. Paired t test was used to assess the statistical significance of pre test and post test. The mean value of (independent variable) bilateral object exploration training group (between pre and post test scores of WMFT (in seconds), Moberg pick up test scores (in seconds), 3-D Common object identification test scores (in seconds)) shows significant difference in improvement than unilateral object exploration training group and conventional stroke therapy group. Paired "t" test values of the bilateral object exploration training group showed significant difference than unilateral object exploration training group, conventional stroke therapy group, but both the control groups did showcase significant difference between their pre and post test values in all variables. In table 02 Analysis of variance (ANOVA) of bilateral object exploration training group showed a significant difference in improvement on hand function in stroke subjects. Analysis of variance in WMFT (in sec) shows the mean square of 388.617 in between the groups, Moberg pick up test (in sec) shows the mean square of 185.450 in between the groups, 3-D common object identification test (in sec) shows the mean square of 972.817 in between the groups.

Table.1: Descriptive analysis

Dependent variables	N	Mean ±S.D	Minimum age	Maximum age
WMFT scores (seconds) Experimental group Control group 1 Control group2	 20 20 20	 48.85±3.117 53.70±3.389 53.25±5.056	 41 49 45	 52 58 60
Moberg pick up test scores (seconds) Experimental group Control group1 Control group 2	 20 20 20	 50.00±3.387 54.10±4.012 55.95±3.364	 41 49 50	 56 61 62
3-D common object identification test scores (sec) Experimental group Control group1 Control group 2	 20 20 20	 43.05±4.513 53.45±6.565 56.30±3.614	 32 33 48	 51 60 60

Table.2:Analysis of variance for groups

Dependent Variable	Sum of Squares	df	Mean square	F	Sig
WMFT scores (seconds) Between the group	777.233	2	388.617	24.931	.000
Moberg pick up test scores (seconds) Between the group	370.900	2	185.450	14.309	.000
3-D common object identification test scores (sec) Between the group	1945.633	2	972.817	38.134	.000

Significant at 1% level (i.e) (p<0.01) in degrees

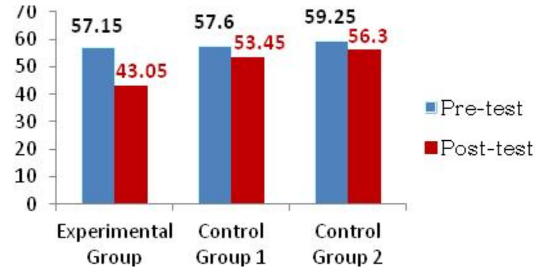

Fig.3: Comparison of Mean Value of 3-D common object identification test

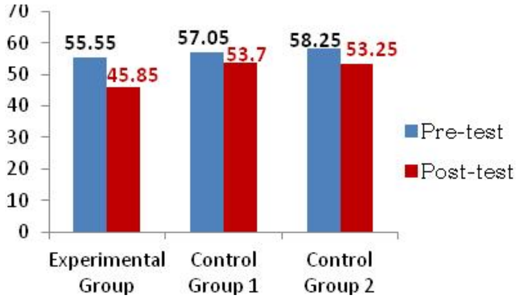

Fig.4: Comparison of mean value of WMFT

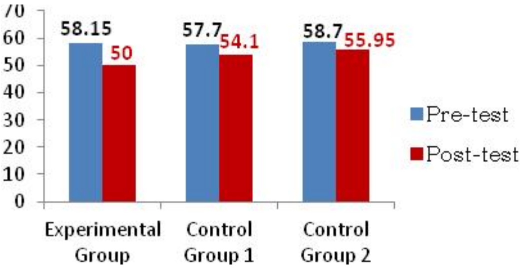

Fig.5: Comparison of mean value of Moberg pick up test

DISCUSSION

Because of the highly variable extent of recovery both neurological and functional during the first months after stroke, it is very difficult to evaluate the effects of therapeutic intervention during this period. For this trial, we therefore choose patients well beyond the period in which effects of spontaneous recovery might be wrongly attributed to therapy [15]

The current study offers a more comprehensive outcome measure and specific treatment tool in developing object explorative skills with the assistance of the unaffected side in stroke rehabilitation, which as shown to improve the dexterity of hemiplegic hand. The current results highlighted that substantial improvement in tactile knowledge and motor ability is seen in subjects trained with bilateral object exploration training though the other two control group showed significant changes between pre and post test, it was noticeable that the experimental group exhibited better object handling skills with lesser trials and early recognition of objects during the course of the research, bilateral hand exploration would have possibly increased the magnitude of the information's about the geometric properties of objects and the procedure of visual blocking would have placed enough demand on the tactile and kinaesthetic senses[16]. A study done by Nicola Bruno et al on haptic perception after a change in hand size (2009) is one of the evidence for our explanation of using both hands being effective by increasing multi-sensory stimulations and large receptive area. It is important to integrate sensory stimulus in functional training of stroke because the efficiency and speed of the (motor) recovery process depends partly on the availability of sensory information provided by motor activity [17].

Tactile object recognition can be viewed as complex information processing that evolves from modality-specific perception of different classes of object features into recognition of objects explored. Training with objects that handled in day today activities serves as early simulated experience for the subjects to enhance their exploratory skills this statement is also supported by a study done by Amy Needham (2002) on infants showed that early simulated experiences improves object exploration strategies in comparison with their inexperienced peer group[18, 19]. The findings of this study reveals that conventional stroke rehabilitation and object exploration training of the affected hemiplegic hand showed improvement, but bilateral object exploration training showed significant improvement in both explorative skills and motor tasks. The limitations of the study were selection of objects for explorative training was few in numbers. Further works will provide a better understanding of the complex interdependencies between tactile input, exploratory training strategies and bimanual handling in neurological subjects.

CONCLUSION

In keeping with our hypothesis, we found that stroke subjects of all three groups showed prognosis which were notable statistically. But the experimental group showed significant improvement and a better transformation of explorative skills to motor performance. We conclude that integration of bilateral object exploration would make hemiplegic hand rehabilitation program more comprehensive and effective clinical implication.

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The authors declare that they have no competing interest.

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