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EFFECT OF FES ON ARM MOVEMENT AND HAND FUNCTION IN TRAUMATIC BRAIN INJURY SURVIVORS

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ABSTRACT

BACKGROUND: *Traumatic brain injury is defined as damage to the brain resulting from external mechanical force, such as rapid acceleration or deceleration impact, blast waves, or penetration by a projectile, leading to temporary or permanent impairment of brain function. Traumatic brain injury (TBI) has a dramatic impact on the health of the nation: it accounts for 15–20% of deaths in people aged 5–35 yr old, and is responsible for 1% of all adult deaths.*
OBJECTIVE: *This thesis examined the effect of arm movement and hand function through application of both FES and conventional therapy in Traumatic brain injury survivors.*
DESIGN: *Pre test/post test experimental design*
SETTING: *Occupational Therapy department, Swami Vivekananda National Institute of rehabilitation Training and Research, Olatpur, Odisha, 754010*
PARTICIPANTS: *20 Traumatic brain injury survivors.(11 right handed and 9 left handed)*

INTERVENTION: Subjects were collected from department of Occupational Therapy, SVNIRTAR.Parents of subjects was explained about the study and informed consent was taken from them. Baseline data were collected for all subjects by using. Jebsen taylor hand function test, The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire. Before beginning the intervention each subjects were randomly divided into two groups as Group A and Group B .Subjects of both groups were provided therapy sessions for 45 minutes per day, 5days in a week for 6 weeks..

OUTCOME MEASURE
- Jebsen taylor hand function test.{JTHFT}
- The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire

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RESULT: The results revealed that functional electrical stimulation (FES) produced a moderate mean treatment effect (p= 0.05; U= 0.023; 95% confidence interval: 0.05 to 0.91). Both the group shows the significant value where as functional electrical stimulation (FES) and conventional therapy comebinly showed better result than the functional electrical stimulation (FES) alone.

CONCLUSION: In conclusion, the most attractive feature of multichannel surface stimulators is that they are non-invasive, often programmable and allow for various muscles/muscle groups to be stimulated simultaneously in physiological patterns. They have a high level of fidelity and are able to produce global upper-limb motions as well as fine finger movements like two pinch grip (thumb and index finger) and tripod grip (thumb, index, and middle finger) using surface stimulation electrodes.

KEYWORDS: FES, TBI, Hemiparesia, transcutaneous, JTHFT, DASH

INTRODUCTION

Traumatic brain injury is defined as damage to the brain resulting from external mechanical force, such as rapid acceleration or deceleration impact, blast waves, or penetration by a projectile, leading to temporary or permanent impairment of brain function. Traumatic brain injury (TBI) has a dramatic impact on the health of the nation: it accounts for 15–20% of deaths in people aged 5–35 yr old, and is responsible for 1% of all adult deaths. TBI is a major cause of death and disability worldwide, especially in children and young adults. Males sustain traumatic brain injuries more frequently than do females.

Traumatic brain injury (TBI) is one of the most common neurologic disorders causing disability, and motor weakness is one of the main sequel, along with cognitive dysfunction and behavior problems. Elucidation of the cause of motor weakness is necessary for successful rehabilitation in TBI; this information enables establishment of scientific rehabilitative strategies, estimation of the rehabilitative period, and prediction of final outcome for patients with TBI.[1,6,8-17]

Many studies have attempted to elucidate the causes of motor weakness in patients with TBI; various methods have been used, including clinical manifestation, brain computed tomography, conventional brain magnetic resonance imaging, or transcranial magnetic stimulation.[1,8-11,18-20] Most of these studies have focused on the specific cause of motor weakness.[8-11,19,20] However, little is known about the classification and elucidation of the causes of motor weakness in consecutive patients with TBI.[1] In addition, many difficulties have been encountered in the attempt to elucidate the exact causes of motor weakness because tools for use in evaluation are limited in that they do not allow for estimation and visualization of neural tracts 3-dimensionally.

The probability and rate of recovery of upper extremity motor function in rehabilitation patients with arm paresis after TBI was closely tied to the initial level of impairment and overall injury severity The use of wrist stretching exercises with protocol with four-week duration performed in adult population with hemiparesia from Encephalic Vascular Accident and extensive area Encephalic Vascular Accident, such as brain injury, incapable of actively extending the affected wrist putting it in neutral position, the maximum degree of extension was kept after the four week period compared to the control group, which performed only conventional rehabilitation without stretching of wrist and fingers, which reduced this amplitude a little, but was not significant ($p < 0.09$). After four weeks of intervention there was improvement in the activity of the limb on the experimental group and it remained the same in the control group, but the difference also was not significant ($p = 0.10$); both groups maintained similar responses to the first assessment in the fifth week, without performing stretching exercises, and in the ninth week with the resuming of the stretching exercises on both groups; no improvements were observed either in the level of pain, in none of the groups along the whole period of intervention

Application of functional electrical stimulation (FES) for therapeutic purposes in rehabilitation settings dates back to the 1960's when Liberson et al. (1961) used an FES system to stimulate the peroneal nerve to correct foot drop by triggering a foot switch, a single-channel electrical stimulation device stimulated the common peroneal nerve via a surface electrode, producing ankle dorsiflexion during the swing phase of gait (Liberson et al., 1961).

Over the years, various grasping protocols have been identified and designed allowing for a wide variety of grasping patterns to be trained with a great deal of fidelity. Currently, the grasping patterns that can be successfully retrained using a transcutaneous multi -channel FES

The FES protocol allowed for individuals with little to no voluntary movement at the wrist and fingers to be able to perform simple tasks while being stimulated with the FES. This is what differentiates FES from other therapies. In the early stages of FES

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therapy, all the movements were performed with the help of FES. The treatment plan and instruction to participants were as follows:

(1) "Imagine hand opening" (or any movement that the therapist would like to train).

(2) "Try to perform the movement using your own muscle strength."

(3) After trying for about 10 s: "Now, try to perform the movement with the help of FES."

Hence, emphasis was put on participants voluntarily attempting the movement while being stimulated with the FES. During therapy when the participants started showing an ability to voluntarily contract certain muscle groups FES for those muscle groups was reduced to a minimum and gradually withdrawn completely. The available channel was then used on other muscle groups that were still weak and needed to be trained. The order in which muscle groups were sequentially "reactivated" was subject-dependent. FES was always delivered while the participants were performing functional tasks, such as grasping a mug, pouring water, holding a pen, etc.

AIMS AND OBJECTIVES

- ➢ To evaluate the effect of arm movement and hand function through application of both FES and conventional therapy in Traumatic brain injury survivors.
- ➢ To enhance arm movement and hand function through FES therapy alone.

ALTERNATE HYPOTHESIS

- ➢ Both the FES and conventional therapy show significant result in recovery of hand function with Traumatic brain injury survivors.

NULL HYPOTHESIS

- ➢ There will be no effect of both therapies in recovery of hand function in Traumatic brain injury patients.

METHODOLOGY

PLACE OF STUDY

The study was conducted at Swami Vivekananda National Institute Of Rehabilitation training and Research, Cuttack Orissa.

STUDY DESIGN: Pre test / Post test experimental design

SAMPLE SIZE: 20 Traumatic brain injury survivors.(11 right handed and 9 left handed)

Group A-10, was taken in FES and **Group B-10** in (FES) and conventional therapy group.

INCLUSION CRITERIA

- Time post injury: >12 Months
- Moderate to severe TBI, with one of the following (as confirmed by medical records):
  1. Post-traumatic amnesia for over 24 hours
  2. Trauma-related intracranial neuroimaging abnormalities (based on radiology reports of the head CT scan acquired acutely)
  3. Loss of consciousness for over 30 minutes
  4. Score of over 13 on the Glasgow Coma Scale (recorded in emergency dept, but not valid if patient was incubated, sedated or intoxicated)
- Has emerged from post-traumatic amnesia (as indicated by review of medical history documents)
- Cognitively oriented (score above 23 on the Mini Mental State Examination)
- One upper limb is more affected than the other, and participant reports impaired upper limb function because of the more affected limb
- The more affected limb is at Stage 3, 4 or 5 of Arm Recovery

EXCLUSION CRITERIA

- < 18 years old at the time of injury
- A history of previous neurological disorder
- A history of significant psychiatric disorder
- The more affected limb is at the Stage 1, 2, 6, or 7 of Arm Recovery
- Pain in the upper extremity during the upper limb function screening
- Active subluxation of the shoulders (i.e., the glenohumeral joint)
- Undergoing treatment for spasticity in the upper limb (e.g. botulinum toxin injection)

OUTCOME MEASURE

- ➢ Jebsen taylor hand function test.{JTHFT}
- ➢ The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire

PROCEDURE

- ➢ Subjects were collected from department of Occupational Therapy, SVNIRTAR.Parents of subjects was explained about the study and informed consent were taken from them. Baseline data were collected for all subjects by using. Jebsen taylor hand function test, The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire. Before beginning the intervention each subjects were randomly divided into two groups as Group A and Group B .Subjects of both

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groups were provided therapy sessions for 45 minutes per day, 5days in a week for 6 weeks. The subjects of Group A had received FES Therapy for 45 minutes. Whereas subjects in Group B had received FES with conventional Occupational Therapy for 45 minutes..At the end of 6 weeks , all the subjects were administered Jebsen taylor hand function test, The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire. were collected as pre and post intervention data. Both pre and post data will be taken for statistical analysis.

Group A (FES): The **FES** training was implemented once a day for 45 minutes from Monday to Friday for four weeks. Each training consistent of three sessions with five minute breaks between two sessions. Each session was performed by an appropriate position, followed by explanation of rules and instructions by the therapist. The stimulation parameters used were the following: (a) balanced, biphasic, current regulated electrical pulses; (b) pulse amplitude from 8 to 50 mA (typical values 15–30 mA); (c) pulse width 250 μs; and (d) pulse frequency 40 Hz (During the intervention, the therapist, at their discretion, adjusted the placement of electrodes and guided the hand movements. The therapist ensured that the movements were functional.

Group B (FES and Conventional therapy): The subject received the following instructions before each session: during this session there are some activities including flexion/extension of the thumb, abduction/adduction of all digits, making a fist/spreading the hand, moving extended fingers backwards and forwards, and moving the hand between the ulnar and radial deviation. Over the years, various grasping protocols have been identified and designed allowing for a wide variety of grasping patterns to be trained with a great deal of fidelity. Currently, the grasping patterns that can be successfully retrained using a transcutaneous multi -channel FES system are:

(1) Palmar Grasp (holding a ball)
(2) Lateral Grasp (holding a tray)
(3) Tripod grip (thumb, index, and middle finger: holding a pen)
(4) Two finger opposition (thumb and index finger: holding a peg)
(5) Lateral Pinch (thumb and index finger: holding a credit card)
(6) Two finger lateral pinch (index and middle finger: smoker's grip)
(7) Lumbrical grip (all four fingers with the thumb: holding a closed book).

DATA ANALYSIS

After collecting all the data, data analysis were done by using SPSS version 23.0 .

Mann Whitney U test were used to analyze the changes in scores Jebsen taylor hand function test, The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire. between group and Wilcoxon signed rank test was used to analyse the changes within the groups. Level of significance was set at $p \leq 0.05$.

RESULTS

The analysis of data gives the following tables showing the demographic characteristic and test results .

TABLE 1 SHOWS DEMOGRAPHIC CHARACTERISTICS OF SUBJECTS

SL NO.	BASELINE CHARACTERISTICS	GR. A	GR B
1	No. of subjects	10	10
2	Age range (years)	25-45	25-45
3	Mean age	34.9 years	35.36 years

TABLE 2 SHOWS DESCRIPTIVE STATISTICS OF OUTCOME MEASURE :

OUTCOME MEASURE	GROUP A				GROUP B			
	Mean test score		Standard deviation		Mean test score		Standard deviation	
	Pre test	Post test	Pre test	Post test	Pre test	Post test	Pre test	Post test
DASH	71.83	58.64	±7.21	±7.81	70.87	43.37	±5.55	±5.21
JTHFT	33.86	28.53	±3.97	±6.18	32.94	21.53	±3.24	±3.73

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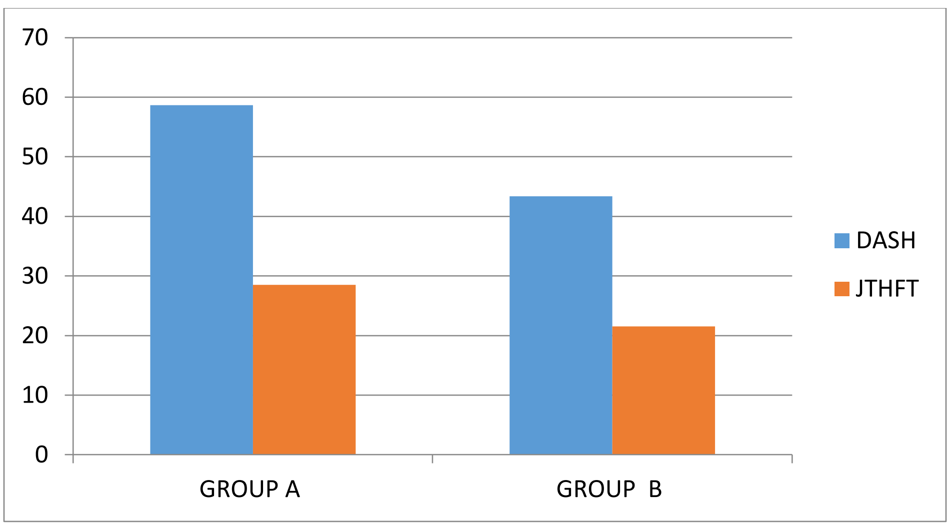
TABLE 3 SHOWS DESCRIPTIVE STATISTICS OF WITHIN THE GROUPS
OUTCOME MEASURE:

OUTCOME MEASURE	GROUP A	GROUP B		
	Mean test score Standard deviation	Mean test score Standard deviation	W	P
DASH	71.83±7.21	70.87±5.55	11.32	**0.54**
JTHFT	33.86±3.97	32.94±3.24	9.78	

TABLE 4 SHOWS DESCRIPTIVE STATISTICS OF BETWEEN THE GROUPS.
OUTCOME MEASURE:

OUTCOME MEASURE	GROUP A	GROUP B		
	Mean test score Standard deviation	Mean test score Standard deviation	U	P
DASH	58.64±7.81	43.37±5.21	13.6	**0.023**
JTHFT	28.53±6.18	21.53±3.73	8.98	



DISCUSSION

Current study presents there was improvement in hand function in both the group. In sub acute stage FES is not beneficial unless physical practice was not there.

The degree of functional recovery of the upper extremity greatly affects the estimation and determination of the degree of assistance necessary to perform the activities of daily living and the level of independence after TBI. In particular, since many tasks in the activities of daily living required the use of the upper extremity, patients who cannot use their hands become to experience physical and mental pain. TBI patients with serious upper extremity paralysis sometimes show repulsion against physical approaches focused on the recovery of paretic extremity functions [Blanton & Wolf, 1999], and this phenomenon sometimes becomes a secondary problem in achieving efficient recovery processes.

Short duration multichannel surface FES is a viable and safe treatment modality that can be successfully applied in patients with neurological conditions. It is important to note that we did not formally investigate safety and feasibility in our clinical trials mainly because transcutaneous FES has been applied in clinical trials for over 5 decades now without any reports of major adverse events.

Basic principles of FES application on the widely accepted belief that mechanism of improvement with this therapy is based on the principles of

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neuroplasticity (Nagai et al., 2016). First and foremost it is strongly recommended that therapy should be started as soon as the medical condition of the patient is stabilized, i.e., preferably in the acute or sub-acute phase post-injury. Secondly, active participation of the patient during treatment is critical. Along with the FES, patients have to make an active attempt to execute the target movement. Third, the movements carried out should be functional and should follow a physiological pattern as closely as possible (movements similar to those of able-bodied individuals). Fourth, therapy should be combined with conventional rehabilitation modalities (example: stretching and strengthening) to reap maximum benefits. Lastly, while no specific dosing study has been conducted,.

All have recovered to mild or no paresis. In fact, a hand with no isolated movement by 2 weeks after stroke has a very small chance of recovery of isolated movements.19 By comparison with stroke patients, although the average time course of recovery was comparable (6.9 weeks for patients with TBI in this study versus 7 weeks for patients with strokeis), later recovery was more likely in patients with TBI. In one study of patients with stroke' maximal arm recovery was achieved by 9 weeks in 95% of the group, whereas more than 20% of patients with TBI in this study progressed to maximal recovery after 8 weeks.

CONCLUSIONS

Arm paresis after TBI is relatively infrequent. Most patients recover by 2 months but later recovery is possible, especially in patients with primarily diffuse brain damage. Recovery is highly related to initial impairment, injury severity, and distribution of brain injury. In conclusion, the most attractive feature of multichannel surface stimulators is that they are non-invasive, often programmable and allow for various muscles/muscle groups to be stimulated simultaneously in physiological patterns. They have a high level of fidelity and are able to produce global upper-limb motions as well as fine finger movements like two pinch grip (thumb and index finger) and tripod grip (thumb, index, and middle finger) using surface stimulation electrodes.

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