EFFECT OF EMG BASED THERAPY ON STROKE PATIENT

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A thesis submitted in partial fulfillment of the requirements for the degree of

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Dedication

Dedicated to my Parents

Acknowledgments

I am thankful to my Creator Allah Subhana-Watala to have guided me throughout this work at every step and for every new thought which You setup in my mind to improve it. Indeed, I could have done nothing without Your priceless help and guidance. Whosoever helped me throughout the course of my thesis, whether my parents or any other individual was Your will, so indeed none be worthy of praise but You.

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ABSTRACT

Stroke is one the main cause of death around the world. Only in USA, someone dies of the stroke in every 4 minutes which is an alarming condition in health sector. The upper limb malfunction is a grouping of muscular feebleness decreased adroitness, non-coordination, loss of senses and abnormalities in motor interaction, that adversely affects the action of happenings of mundane livings. Many therapies are underway to treat the stroke patients. One of them is traditional way and the other is EMG based therapy. In this research, we focused on the EMG based therapy on stroke patients and its relativity with the traditional therapy. EMG based therapy was implemented on 06 subject and it was found that EMG based therapy was significantly better traditional therapies. There has been seen great improvement in the pre-assessment and post assessment tests. Majority participants have showed significantly improved scores in post-assessment tests as compared to pre-assessments test. This shows great potential of EMG therapy in stroke patients. It was also observed after therapy that patients were slightly able to perform Activities of Daily Living such as eating, drinking, bathing, writing etc. Another major benefit for this therapy was it doesn’t require any specialization. Anyone at can home with some practice can perform EMG at homes. Another advantage of this therapy was that EMG device readily available and are available at very low cost.

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CHAPTER 1: INTRODUCTION

Stroke is one of the leading factors of death in the whole world. It also has worst effects on the motor functioning of the person which consequently effects the daily activities of life. It is estimated that about 85 percent of stroke surviving patients suffered from hemiplegia out which motor function disability of upper limb extremities was experienced by 69 percent of patients [1-7]. Approximately, 800,000 people in the United States suffered from Stroke every year and is increasing continuously [2-12].

Stroke is defined as the injury of the brain tissues due to eruption of blood vessels or due to clotting of blood in the blood arteries which causes reduced supply of blood to the brain cells. These types of strokes are called ischemic stroke and hemorrhage stroke respectively. Both of these stroke injuries on the motor and premotor cortex as well as on the motor tracts of cerebellum or cerebrum results in motor impairments. [3-20].

The most common post stroke effect is the motor function of the body in which the movement of the muscles of the patient's face, upper limbs and lower limbs on one side are badly affected. There are various techniques and methods which are in use to treat the stroke patients and bring them back to those patients to their normal life. Most of the therapies are specific to the movement of arm, however, therapies regarding recovery of upper extremities are limited.

1.1 LITERATURE REVIEW

The malfunctioning of upper limbs is a common indication of any stroke. The upper limb malfunction is a grouping of muscular feebleness, decreased adroitness, non-coordination, loss of senses and abnormalities in motor interactions, that adversely affects the action of happenings of mundane living (ADLs). The manual action is responsible for most subtle activities in day-to-day chores and hand movement shortfalls severely impact the performance of a variety of everyday tasks (Gladstone, Danells & Black 2002). The gradual weakening in functional self-sufficiency for post-stroke does not mere lead to a worsening in eminence of life, it also poses heavy compression on caregivers. In this way, the refurbishment of upper limb functionality is recognized as an absolute precedence for any patient of stroke, caretakers and for medical professionals as well (Chang &Kim 2013).

The EMG-driven manual robot showed that it increases intended motor control, decreased muscle co-ordination and improved the motor functionality of the upper limbs (Hu, Tong, Wei, Rong, Susanto & Ho, 2013), although there were few studies comparing mostly the relations between EMG assisted therapies and task-based training in patients of stroke. Task-based training is a patient-centered as well as feature-oriented intervention, whose effectiveness is acknowledged on motor restoration after a stroke. It has been suggested for routinely incorporation along with mundane practice in professional therapy for stroke restoration therapy (Almhdawi , Mathiowetz, White , delMas 2016).

A meta-analysis describes how EMG-induced ES is compared to conventional therapy and presents an improvement in upper limb impairment in people who have had a stroke for more than 3 months. The advantages in the first month and the comparison of the effects of the different EMG stimulation protocols are still unclear. These authors suggested that EMG-ES leads to greater gains in superior limb impairment following a stroke (Silva, Piscitelli, Norouzi, Batalla, Archambault & Levin, 2009). EMG-MES has also been investigated in motor recycling programs and for the use of the arm and hand in stroke patients (Kapadia, Moineau & Popovic 2020).

1.1.1 EFFICACY OF EMG AS COMPARED TO CONVENTIONAL METHODS

A study was carried out for the evaluation in terms of the application of electro-encephalogram (EEG) biofeedback (neuro-bio-feedback) or electromyographic (EMG) biofeedback while using conservative occupational therapy (OT) on the improvement of manual function in stroke patients. Patients in the neurofeedback and EMG-biofeedback groups showed hand improvement similar to conventional OT. Further studies are suggested to assign the best protocol for neurofeedback and EMG-biofeedback therapy.

Research was conducted for exploring the effects of classical EMG- predicated pattern acknowledgment approach which could be used to prognosticate cases' purposes however, tried for inducing thing-oriented movements in the perpendicular muscular plane. Results reveal that using EMG pattern acknowledgment approach was not practical to crack movements of muscles in patients under study with any neurological injury analogous as a stroke. Relatively than estimating stir from EMGs, upcoming therapies should improve the operation of co-ordination signals to descry and construe the usual and irregular muscle movement patterns and give response for their accurate recovery (Cesqui, Benedetta 2013).

Although, Electromyography (EMG) biofeedback has been currently employed in different beneficial therapies coming between groups for spinning move persons getting care, operation of making observations on its effects has been being without, not there. Most currently in existence studies are limited to purposes, uses of the lower extremities, and operation of making observations on upper extremity able to use getting loss back using EMG biofeedback training is limited. as an outcome of that, a learning process put questions to the effects of training using EMG biofeedback on swimming move persons getting care' upper extremity purposes, uses. A comparison of the learning process groups let be seen which were based on experience group observed greater getting more out in upper edge purpose, use after practice in all exams made a comparison of to the control group; however, there was no important point or amount different regarding the activities of mundane living within the 2 clusters. In this way, spinning move persons getting care letting in getting much out EMG biofeedback showed more important upper extremity able to use getting loss back than those who only received old and wise get-well therapy (Kim, 2017).

The impact regarding particular EMG biofeedback action conventionally based on evaluated variations in neuromuscular measurements and utilitarian exercises were inspected amid the upper edges of 22 persistent patients in stroke cases with each getting 60 input preparing therapies. Inveterate patients of stroke who picked up highest utilitarian usage through the biofeedback intercession at first experienced more noteworthy dynamic run of movement for every main upper limit linked joints and relatively less over activity inside ordinarily spastic joints. Electro-myographic (EMG) response can be central to all significant changes amongst the selective constant patients of stroke leading to significant benefits to other patients as well (Steven , Binder-Macleod, 1983).

According to Kim, (2017) more than 85% patients of stroke experience hemiplegia with exceeding 69% among these patients involvement useful engine inability of the upper limits. Utilitarian engine inability recognizably shows up within the upper extremities instead of within the lower limits (Shumway-Cook, 2006) but the harm to the center cerebral supply route suppling ample blood to the head portion in regulation of the engine capacities of the superior limits and the fingers including hands which curtails 75% of the whole in charge of stroke; minor recuperation of the subordinal extremities empowers utilitarian walk, though within the recuperation of upper limit functions, recovery of diminutive capacities (e.g., get a handle on and control) which of the distal parts is needed (Han, Choi, & Kam, 2009). In resultant of it, the superior limits see such as they have recouped lesser than the subordinate limits. For the recuperation of upper limit capacities in stroke patients, assorted treatment strategies are being examined (Armagan, Tascioglu, & Oner, 2003).

Recently Kang, (2013) has investigates the range of data innovation (IT) which has given strategies and administrations for recovery as well as works out for progressing stroke patients' wellbeing. Amongst these therapeutics, EMG or electromyography response is among the mechanically particular substance in relation to the information technology industry and work out restoration area as suggested by Kang, (2013). In this manner, it is recognized as dedicated industry in combination of the prevailing substance of alike businesses as games/public wellbeing along with savior (Koo, Park, Heo, 2011).

Electromyography biofeedback gives visual and sound-related data on strong withdrawal or developments on a real-time premise, subsequently successfully keeping up suitable muscle compression and body arrangement and actuating typical movements (Koo, Park, Heo, 2011). Input on electronic exercises of the joints including muscles is given outwardly and verbally, such that stroke patients can also acquire how to alter the involvement of the solid joints themselves (Ng, Zhang, Li, 2008). In any case, until as of late, treatment utilizing EMG or electromyography responses has been directed differently for restorative intercessions among patients of stroke (Barcala, Grecco, & Colella, 2013; Kim, Lee, & Lee, 2015; Lee, & Kim, 2013).

1.1.2 SURFACE EMG SYSTEM

Superficial EMG or electromyography gives a invasion free opening into the anxious framework which could be utilized for screening muscular movement, however, it is seldom utilized for intense repair (Steele, Papazian, & Feldner, 2020). The findings of Steele, Papazian, & Feldner, (2020) concluded that recent trending innovation could be utilized to securely and obtrusive free screening of muscular action, indeed in patients of stroke with no any divergent muscular action with conventional therapeutic appraisals and observing through EMG might offer assistance to professionally measure the muscular action, trail recuperation, along with educate restoration. An EMG framework can unpretentiously screen muscle action whereas the understanding and clinical group proceed with standardized care but with intense situation offerings interesting trials in conveying such innovation.

Ogul, Coskunsu, Akcay, Akyol, Hanoglu, & Ozturk, (2021) explored the impacts of electromyography (EMG)-driven mechanical treatment on the recuperation of the hand in a stroke case enduring 9 a long time and found that the normal EMG measured from FDS expanded from 0.093-0.133 mV finished with the conclusion that the enhancement accomplished 9 a long time afterward with 15 sessions of restoration recommends that change may be conceivable for inveterate stroke patients. Utomo, Triwiyanto, Suhartini, Luthfiyah, & Mudjiono, (2018) has prepared the stroke quiet autonomously employing a mechanical exoskeleton based on electromyography (EMG) flag and the EMG flag was collected on the biceps utilizing expendable anodes (Ag/AgCl) on the five subjects who have a post-stroke were utilized in this study and provided a diagramed block of the study which was shown as follows to better understanding of the EMG therapy:

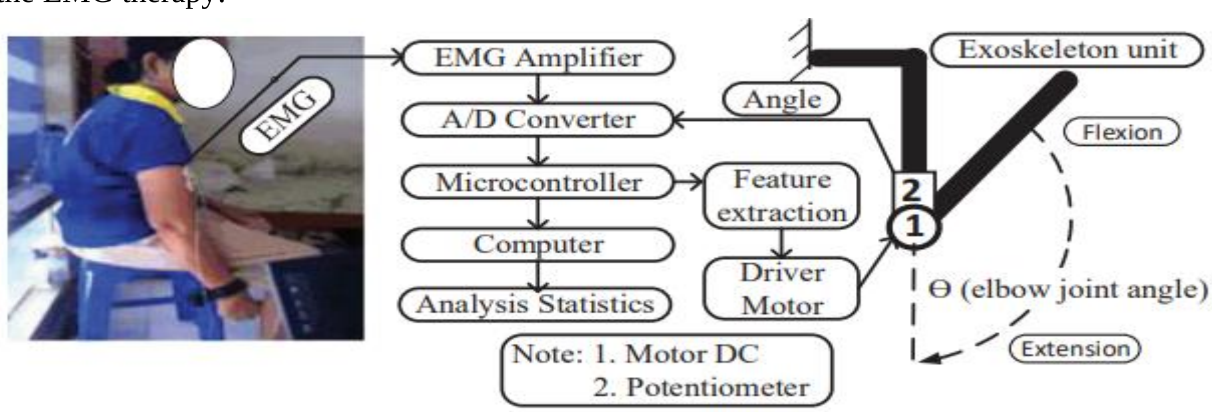

Figure 1 Block Diagram of the EMG Therapy

According to Noor, Waris, Gilani, Kashif, Jochumsen, Iqbal, & Niazi, (2021) stroke may be a cerebrovascular illness (CVD), which comes about in hemiplegia, loss of motion, or passing and expectedly, a stroke quiet requires delayed sessions with physical advisors for the recuperation of engine work for which different home-based rehabilitative gadgets are moreover accessible for upper appendages and require negligible or no help from a physiotherapist but the potential utilize of surface electromyography (sEMG) as a controlling instrument for the improvement of a home-based lower appendage rehabilitative gadget for stroke patients demonstrates way better comes about. Suhaimi, Rashidah & ADNAN, Nazrul H. & Asyraf, Fakhrul & Khairunizam, Wan & Desa, Hazry & Abu bakar, Shahriman & Abubakar, Juliana & Mohamad Razlan, Zuradzman & A.R, Aswad, (2014) considered the EMG-based muscles movement for stroke restoration and investigated the utilize of 12 anodes which were connected to the correct arm of the subject incorporates deltoid, bicep, tricep, flexor and extensor for an exploratory comes about confirmation that it is likely to deliver development grouping for stroke restoration based on each muscle movement through EMG movement.

According to Piyus, Cherian, & Nageswaran, (2017) 15 million in world population experiences stroke per Anum and approximately 9 million people related to stroke survivors experienced slight to severe disability each year. The inability of upper body joints functionality in survivors from stroke yet remained with major reintegration task and the projected EMG oriented FES arrangement. Piyus, Cherian, & Nageswaran, (2017) used it for operative superior limbs motor restoration in post stroke upper limb therapeutics. FES incitement is subordinate on the plentifulness of the EMG flag obtained from the unpretentious upper appendage muscles from the hemiplegic understanding. This proportional operation dispenses with the unwanted harm to the skin of the patient by creating jolt inside extent to deliberate EMG biofeedback signals. This highlight overcame the impediments as of now accessible manual engine re-education frameworks and concluded that EMG-activated FES is comparatively prolific than non-activated FES in moving forward the superior appendage capacities in patients of stroke regarding deliberate muscle compression and muscular quality of the influenced fingers. The complete thought has been conveyed in a fetched viable way to deliver get to an expansive populace of stroke patients with after stroke which was shown in the following diagram:

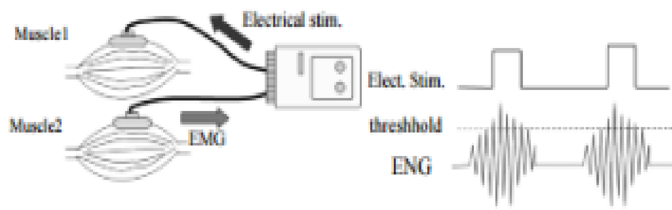

Figure 2 Schema for EMG Therapy

Klein, Li, Hu, & Li, (2018) FES incitement is subordinate on the adequacy of the EMG flag procured through the unpretentious upper appendage muscular of the hemiplegic quiet. This comparable operation dispenses with the uninvited harm to the skin of patient by creating boost in extent to deliberate EMG biofeedback signals. This include incapacitates the impediments of as of now accessible manual engine re-education frameworks and concluded that EMG-activated FES is comparatively fecund than non-activated FES in making strides the superior appendage capacities in patients of stroke in terms of deliberate muscle compression. In a case study Lu, Tong, Shin, Li, & Zhou, (2017) FES strength of the influenced hand. The entire thought has been conveyed in a taken a toll viable way to provide get to a huge populace of patients with post-stroke. Qian, Hu, Lai, Ng, Zheng, & Poon, (2017) assessed the impacts of one month (20 sessions) of EMG-oriented NMES collective with automated help, focusing on the elbow, wrist, and fingers of subacute stroke survivors. EMG parameters, counting the co-contraction file and the actuation level of focused on muscles were utilized to screen the muscular synchronization designs. They concluded that the NMES in combination with mechanical preparing might accomplish higher engine results at the distant muscles and joints with more viable diminishment in muscular toning than conventional treatments. Androwis, Pilkar, Ramanujam, & Nolan, (2018) utilized novel EMG investigation (Burst Length Closeness Record) to measure the escalated and effectiveness of muscular enactment amid a solitary session of mechanical walk treatment in intense survivors of stroke. The creators appeared that automated outer most skeleton can diminish the soleus muscle and rectus femoris muscular movement within the influenced appendage amid position stage, and can too move forward the effectiveness of muscular enactment within the influenced limb.

Camona, Wilkins, Drogos, Sullivan, Dewald, & Yao, (2018) concluded EMG-oriented NMES task-based arm/hand preparing (seven weeks) progressed fingers opening and utilitarian utilize in inveterate survivors of the stroke with direct to extreme engine impedances. Utilitarian enhancement was twinned with utilitarian restructuring within the ipsilesional essential sensorial motor cortex. In a research which used a case study on sub-acute stroke subjects. Zheng, Peng, Xu, Li, & Wang, (2018) evaluated cortico-muscular linking between EEG and EMG (biceps) biofeedback signals while elbow flexor prior and afterwards one month of consistent physical and professional therapy. Corticomuscles consistency was expanded within the influenced appendage with practical development, but not within the non-affected appendage. These comes about represent that stroke survivors with serious engine disabilities might still have the capacity to progress the functioning of hand in the event that fitting intercessions are utilized to actuate neural versatility. Banks, Huang, Little, & Patten, (2017) enumerated superficial EMG co-tightening of agonist-antagonist muscular pairs in three manners (no standardization, regularized to the maximal

EMG for the walking cycle, standardized to the Mwave) and resolute their connotation with gait damage while walking on treadmill.

Pilkar, Ramanujam, & Nolan, (2017) employed divergent EMG-oriented guides to enumerate the impacts of a foot dripped stimulator for muscular activation while walking for more than six months duration of community gait. A wavelet-oriented time and frequency analysis method was applied to quantify instigation changes of multiplex ankle muscular in chronic survivors of stroke. The results suggest modifications for motor component conscription strategies subsequently foot dripping stimulator usage. The consequences established the usefulness of a foot dripping stimulator for reintegration intervention which might endorse motor regaining functionality in accumulation to dropping foot dripping simulator. Superficial EMG in combination with other biofeedback signals chronicled incidentally or centrally delivers a medium to evaluate mechanisms for motor weakening. Li, Zhou, Aruin, (2007) examined motor collaborations while arm feat oriented on superficial EMG tapes from multiplex muscles and associated with reaching motor synergies. They were likely to perceive task-oriented deficits in gripping movements in post-stroke conditions. Ma, Chen, Mao, Huang, Song, & Li, (2017) considered lower limb muscular movement while hindrance crossing when superficial EMG was using in chronic survivors of stroke. EMG movement of the foremost limb throughout the swing point was greater in each muscles during the stroke associated to the control set, and TA action amplified with hindrance height in both sets.

Panel, (2006) also recommended Electromyographic biofeedback (EMG-BF) for the treatment of various conditions after a stroke, making patients more aware of muscle activity and helping to control the level of muscle contraction applied. Hu, Rong, Li, Nam, Wei, Cheung, Wai, & Hu, (2018) along with Nam, Rong, Li, Cheung, Ngai, Cheung, Pang, Li, Hu, Wai, (2020) developed an innovative EMG-based exoneuro-musculoskeleton (ENMS) for personal movement of superior limb reintegration in post-stroke newly. Captivating the recompenses of exterior skeleton, pneumatic muscular, and NMES, the advanced system is insubstantial, compact, and having power-sufficient consumption. The arrangement could assist the extension-flexion movement of the elbow including wrist, and fingers joint with voluntary exertion control via EMG. The structure comprises of an elbow component along with a wrist/hand component which could work together as well as separate. The wrist/hand unit can also work self-sufficiently as an EMG-based wrist/hand ENMS (WHENMS) for assisting wrist/hand activities while training.

Zhou, Klein, Zhang, Li, & Li, (2020) has presented an examination of Electromyography (EMG) on motor unit alterations after stroke patients. With technical advances in both electrode design and signal processing, electromyography (EMG) has broad applicability for assessing properties of single muscle fibers, motor units, gross muscle, or muscle groups. Zhou, Klein, Zhang, Li, & Li, (2020) has identified different EMG techniques have been applied to assess paretic muscle changes in stroke patients, and also a number of abnormalities have been identified. Ang, Huang, & Low (2009) also researched by means of EMG (electromyography) expedient to research the movement of skeletal muscular tightening for numerous purposes such as for motion identifying, hand restoration and finally concluded that EMG (electromyography) acts as an instrument which was able to communicate or perceive the electrical biofeedback signals produced by electronically or neurologically activated muscular cells. The yielding signals can be examined to perceive the muscular movement level and medicinal irregularities even to scrutinize the biomechanics of humanoid.

Ahamed, Sundaraj, & Ahmad, (2012) studied the superficial electromyography of the superior arm of humanoid to confirm the inconsistency in diverse muscle site and unlike age grouping. The age sets comprise of three categories which comprised of adolescent group, vicenarian group and tricenarian group. The investigator evaluated the mean as well as standard deviation and variation co-efficient to analyze the muscular activities which are beneficial for restoration concerns. Pakosz, (2011) studied the EMG biofeedback signals investigation for explicit functional activities which can be shots and propagates while basketball play time. The patients are players of basketball with diverse level of skill in basketball play time. Flexion and extension movement was taken into attention for every activity. This research verified that EMG-based activation biofeedback signals depend on the category of activity completed by the muscles.

Cesqui, Benedetta et al., (2013) investigated the use of electromyographic (EMG) signals in robot-based stroke neurorehabilitation to enhance functional recovery and the findings suggested that instead of applying the EMG-based biofeedback signals to differentiate the intentions of the patient, these signals could be utilized to progress an online method that delivers a feedback on any fault in the muscular activation designs. EMG-based biofeedback signals could permit to envisage in advance the anticipated motor task as the signals continuously flinch numerous milliseconds prior to any action instigation but this opportunity could be extremely prejudiced by explicit deficits. Numerous approaches have been established in order to evaluate diverse structures of the activities from muscular movement that were joint angles, stiffness, and velocity torques (Akazawa, & Okuno, 2006; Bizzi, Accornero, Chapple, & Hogan, 1984; Choi, & Kim, 2007; Graupe, Salahi, & Kohn, 1982; Karlik, Tokhi, & Alci, 2003; Wyss, & Pollak, 1984; Zecca, Micera, Carrozza, & Dario, 2002). Cheung, Piron, Agostini, Silvoni, Turolla, Bizzi, (2009) proposed that the valuation of muscular interactions should be employed to estimate diverse therapeutic modalities for after stroke restoration and these outcomes endorse the clue that EMG-based biofeedback signals might be used to augment any robotic therapeutics. Although the usage of EMG-activated signals for any biofeedback in stroke restoration has been moderately contentious but scarce efforts have been completed to mix them with robot therapeutics so far (Armagan, Onur, Tascioglu, Funda, Oner, & Cengiz, 2003; Moreland, & Thomson, 1994; Prevo, Visser, Vogelaar, 1982).

According to Jochumsen, Niazi, Zia-ur-Rehman, Amjad, Shafique, Gilani, & Waris, (2020) head- and muscle-activated exterior skeletons have been projected as a resources for training of motor muscles after any stroke. With the likelihood of execution for diverse movement categories with an exterior skeleton, it is pretty likely to familiarize task unpredictability in training nevertheless It is pretty difficult to interpret diversified movement types instantaneously from head activity, it might be conceivable from residual muscular activity that several patients have or rapidly recuperate. This study explores whether nine disparate motion modules of the hand including forearm could be interpreted from forearm EMG-based signals in fifteen patients having stroke. Three networks of superficial EMG-based biofeedback signals were verified throughout the following motion modules: Hand close, Wrist Extension, Hand Open, Wrist Flexion, Pronation, Supination, Lateral Grasp, Rest and Pinch Grasp. Six replications of every motion session were completed on two separate days. Hudgins time-sphere features were mined and differentiated using lined analysis of discriminant and auto-encoders, and raw EMG-based was categorized with convolutional neuron networks. It was concluded that nine movement sessions could be decrypted from residual of EMG-based signals, with auto-encoders as the best cataloguing approach. These results were consistent across days which might have inferences for the expansion of EMG-controlled exterior skeletons for training in the home of the patients.

Forms of recovery can be extremely inconstant and unpredictable throughout the first week of post-stroke time (Kwakkel, Kollen, & Lindeman, 2004). The theory of Twitchell, (1951) explains that by means of superficial electromyography (EMG)-based recordings to screen muscular activity provisions the use of EMG-based therapy. The investigator make use of EMG-based recordings from major arm muscles to plan usual patterns of regaining. The investigator reveals that flexion was usually initial observance and regaining generally proceeded from proximal joints to distal joints, though the outlines of recovery were extremely inconstant. The researcher has observed twenty five patients in which seventeen patients could not initially perform any movement of the arm. The author frequently could not able to detect muscular activity among these patients with EMG-based therapeutics, although only observed for brief periods of time during particular movements. Whether recent EMG-oriented sensors or prolonged monitoring might recognize contractions for stroke patients remained unidentified. Bolek, (2012) concluded that wearable devices may deliver more comprehensive quantifiable measurements in severe care regarding stroke. Professionals and researchers have documented the latent benefits of EMG-driven therapeutics as a predictive implement, but trials in assessing EMG-driven biofeedback signals and installing this technology have partially wider usage (Feldner, Howell, Kelly, McCoy, & Steele, 2019; SHEA, & WOODS, 1955).

Hesam-Shariati, Trinh, Thompson-Butel, Shiner, McNulty, (2017) revealed the EMG-based biofeedback sensors technology as a superior means for clinically assessments among stroke patients because it bears the potential to recognize vicissitudes in forms of motor functions which are not elsewhere evident. EMG-based sensors have been evolved that could be wear out for prolonged periods of time and are combined with sensors to instantaneously screen the movements of muscle and joints (Yamagami, Peters, Milovanovic, Kuang, Yang, Lu, & Steele, 2018; Zhang, Chen, Li, Lantz, Wang, & Yang, 2011; Giuffrida, Lerner, Steiner, & Daly, 2008; Jeong, Yeo, Akhtar, Norton, Kwack, Li, Jung, Su, Lee, Xia, Cheng, Huang, Choi, Bretl, Rogers, 2013). These innovations deliver promising chances to inflate upon the observations of Twitchell and apply wearable sensors for improving care of stroke patients. Papazian, Nick, Baicoianu, Keshia, & Peters, (2020) also studied regarding the use of electromyography (EMG) in severe stroke care to recognize muscle activity in stroke patients with no apparent activity while medical examination and concluded that muscular activity can be noticed with superficial EMG-based recordings throughout standardized care, even for survivors of stroke with no visible activity by medical examination.

CHAPTER 2: METHODOLOGY

2.1 SELECTION OF SAMPLE:

A clinical study was conducted on the patients with post stroke disabilities. This study includes 6 patients. The inclusion criteria involve age limit between 18 years and above and the duration between the stroke attack and this study is not more than 6 months. The inclusion criteria also include that the patients have no other neurological disease including multiple stroke attacks and that the patients are willing to join this study. The patients are selected from Pakistan Institute of Medical Science, Islamabad. The purpose, methodology and protocol of the study was discussed with the medical officials of the hospital and the patients. The consent of the patients is taken for study. The name and other confidential information related to patients are used only for this study purpose only and is strictly protected against misuse. The patients have been assigned name from A to F.

Age	18 – 50 yrs
Stroke History (Duration)	Greater than 3 months but less than 6 months = 5 Less than 3 months = 1
Gender	M = 4 F = 2
Stroke Effected Side	Right Side = 2 Left Side = 4

Table 1: Attributes of Patients Selected for study

2.2 STUDY DESIGN:

Multiple assessment tests have been done before and after the EMG driven therapy. These tests include Fugl Meyer and Action Research Arm Test (ARAT) for assessment of motor function (Table-2), Block and Box test and Nine Hole Peg test for the assessment of dexterity, Arm Motor Ability Test (ABAT) and Motor Activity Log for assessment of Activities of daily living.

<table>
<tr><td rowspan="2">Motor Function Test</td><td>Fugl Meyer Assessment</td><td>✓ Movements = 23
✓ Items = 33
✓ Categories = 4
(Shoulder / Elbow / Forearm, Wrist, Hand / Finger, Coordination)
Grading System = 3 (0 – 2)
• Unable to execute = 0
• Partial Ability to perform = 1
• Close to normal ability to perform = 2</td></tr>
<tr><td>Action Research Arm Test (ARAT)</td><td>✓ Items = 19
✓ Functional Areas = 4
(grasp, grip, pinch, gross movement)
✓ Grading System = 0 – 3
(0 = no movement to 3 = normal performance)</td></tr>
</table>

Table 2: Motor Function Tests – Fugl Meyer Assessment Test and Action Research Arm Test

Dexterity	Block and Box Test	✓ Tasks = 1 ✓ Scale = 150 small wooden boxes ✓ Test Duration = 60 seconds ✓ Grading = Number of blocks moved (movement of wooden blocks from one compartment to other compartment)
	Nine Hole Peg Test	✓ Tasks = 1 ✓ Duration = Time between taking pegs from container and put them in peg board ✓ Grading = low to high (lower time taking on completing the task, higher the score and vice versa)

Table 3: Dexterity – Box and Block Test, and Nine Hole Peg Test

Activity of daily living	Motor Activity Log	✓ Tasks = 30 (utensils handling, hair combing, shirt buttoning etc.) ✓ Scale = 0 – 5 (Complete inability to ability)
	Motor Assessment Scale	Tasks = 8 (sitting, walking, lying etc.) Scale = 0 – 6 (suboptimal motor performance to optimal motor performance)

Table 4: Activity of Daily Livings – Motor Activity Log and Motor Assessment Scale

2.3 MOTOR FUNCTION TEST:

2.3.1 FUGL MEYER ASSESSMENT:

All the patients have been assessed through Fugl Meyer Assessment test. It takes 40 – 50 to complete the assessment on each patient. The procedure of the assessment was described to each patient. The scores achieved by each patient are described in table below.

Patients	**Score**	**Grading**
Patient A	88	Moderate
Patient B	92	Moderate
Patient C	65	Marked
Patient D	48	Severe
Patient E	61	Marked
Patient F	92	Slight

Table 3: Fugl Meyer Assessment Before Therapy

The score of the patients has been calculated out of 100 and the severity of the stroke is based on the FMA Total motor scores (Fugl-Meyer, 1980).

2.3.2 ACTION RESEARCH ARM TEST:

All the patients have been assessed through ARAT. It take 25 – 30 minutes to complete the test for each patient. The procedure of the test was briefed to all the patients. The scores achieved by each patient is described in table below.

Patients	**Score**	**Grading**
Patient A	28	Moderate Ability
Patient B	31	Moderate Ability
Patient C	19	Low Ability
Patient D	14	Low Ability
Patient E	17	Low Ability
Patient F	49	High Ability

Table 5: Motor Function Test Grading

2.4 DEXTERITY:

2.4.1 BLOCK AND BOX TEST:

Patients	**Score**	**Grading**
Patient A	100	Moderate Ability
Patient B	94	Moderate Ability
Patient C	65	Low Ability
Patient D	72	Low Ability
Patient E	53	Low Ability
Patient F	122	High Ability

Table 6: Block and Box Test Grading

2.4.2 9 HOLE PEG TEST:

Patients	**Score**	**Grading**
Patient A	4	Low
Patient B	6	Moderate
Patient C	3	Low
Patient D	5	Moderate
Patient E	8	High
Patient F	3	Low

Table 7: 9 Hole Peg Test Grading

2.5 EMG THERAPY:

The EMG based study was conducted in the diagnostic laboratory of Neurological Department of Pakistan Institute of Medical Sciences (PIMS), Islamabad. The process takes 20-25 minutes on each patient. The process includes multiple types of movement of the upper limbs. For this experiment, 4 channels surface electrode which was attached to the arms of the patients. The point of attachment of electrode on arm are flexor carpi radialis and biceps brachii in the upper arm and triceps brachii, extensor carpi radialis brevis, extensor digitorum and extensor carpi ulnaris of the forearm. The recordings were observed commercial recording system used by the neurological department of PIMS. The whole procedure was done for 25 days.

The procedure starts with the patient A and goes through the patient F. Each patient was instructed to perform five functions using their upper limbs. The functions are adduction, abduction, upper limb flexion, upper limb extension and arm to the front. All the functions were performed by each patient twice and the recording of were observed.

CHAPTER 3: RESUTLS

The EMG driven therapy given to the patients for 25 consecutive days. The purpose of this therapy was to stimulate the muscles of the post stroke patients and to study the outcomes of the stimulation. It was expected that the after giving EMG driven therapy to the post stroke patients, these patients have had improvement in the movement of their muscles of the upper limbs so that they can perform their Activity of Daily Living such as eating, drinking, bathing, writing etc.

After 25 days of therapy, all the assessment tests which were done before the therapy has been done again to understand the extent of the improvement in the post stroke patients. All the patients show some improvement and have relatively good scores in the post therapy assessment tests. In Fugl Meyer Assessment test, patient A and B improved the score from 88 to 93 and from 92 to 96 respectively and shows the improvement in all the categories. Patient C scored 65 to 68, patient D score remains same i.e., 48, patient E scored from 61 to 67 and patient F scored from 92 to 95. The difference in scoring before and after therapy shows that patient C with severe type of stroke shows no improvement in Fugl Meyer Assesment test.

Patients	**Before Therapy**	**After Therapy**
Patient A	88	93
Patient B	92	96
Patient C	65	68
Patient D	48	48
Patient E	61	67
Patient F	92	95

Table 8: Fugl Meyer Assessment Before and After Therapy

Action research arm test (ARAT) score of patient A before therapy is 28 and after therapy is 32, patient B from 31 to 33, patient C scores from 19 to 24, patient D scores from 14 to 15, patient E scores from 17 to 22 and patients F scores from 49 to 49.5.

Patients	**Before Therapy**	**After Therapy**
Patient A	28	32
Patient B	31	33
Patient C	19	24
Patient D	14	15
Patient E	17	22
Patient F	49	49.5

Table 9: Action Research Arm Test Before and After Therapy

In block and box test, 4 out of 6 patients shows improvement in their score. The patient A scores 100 before therapy and the score remains same after therapy. Patient B scores 94 before therapy and 97 after therapy which shows improvement in patient B. Patient C scores 65 before therapy and 72 after therapy. The patient C has shown a very significant improvement in his score. Patient D scores 72 before therapy and 73 after therapy shows a very slightly increase in score. Patient E scores 53 before therapy to 65 after therapy. In this assessment test, patient E has the most significant improvement in his scores. Patient F scores 122 before therapy and 125 after therapy. Patient F has already shown high abilities this assessment test.

Patients	Before Therapy	After Therapy
Patient A	100	100
Patient B	94	97
Patient C	65	72
Patient D	72	73
Patient E	53	65
Patient F	122	125

Table 10: Block and Box Test Before and Therapy

In 9-peg hole test, all patients show improvement in their score. The patient A scores 4 before therapy and 6 after therapy. Patient B scores 6 before therapy and 7 after therapy which shows improvement in patient B. Patient C scores 3 before therapy and 4 after therapy which makes the patient C in still in low grade. Patient D scores 5 before therapy and 7 after therapy shows a decent increase in score. Patient E scores 8 before therapy to 9 after therapy. Patient F scores 3 before therapy and 6 after therapy which shows that patient F shows significant improvement and put that patient from low ability to moderate ability in this assessment.

Patients	Before Therapy	After Therapy
Patient A	4	Low
Patient B	6	7
Patient C	3	4
Patient D	5	7
Patient E	8	9
Patient F	3	6

Table 11: 9 Hole Peg Test Before and After Therapy

CHAPTER 4: DISCUSSION

The purpose of this study was to verify the impact of EMG based therapy on the upper extremity functions of patients survived from the stroke and the effect of this EMG therapy in rehabilitation of upper extremity functions in stroke patients having in view to perform their daily activities. In addition, this study aims to present a converged systems in which rehabilitative training is performed using computer technology-based content. Electromechanical biofeedback was applied to the forearm of the patient on the paralyzed side. Upper extremity function and the patient's activities of daily living were assessed by different assessment tests before and after therapy and results are compared. According to the results, the difference of scores before and after the therapy was significant in majority of the patients. Chae et al. and Lourencao, Battistella, de Vrito, Tsukimoto and Miyazaki also reported significant difference before and after EMG therapy in their research.

According to the results of examining the impact of EMG bases therapy on stroke patients, the difference was significant in all the 6 patients on which the study was conducted, consistent with the results of the present study. The results in addition, Shin and Han, Choi and Gam also found that EMG based therapy is effective on upper limb function in stroke patients. Similarly, EMG based therapy had a positive effect on the upper extremity functions of stroke patients in the present study. Furthermore, the present study compared the daily living activities of the patients included in this study and found significant improvement in their daily living activities after getting therapy as compared to before therapy. However, it is also found in this study that the EMG therapy in patients with very low score in assessment tests before therapy and have severe type of stroke does not show any significant improvement after therapy. As compared to previous studies, it was also observed that the patients with acute stroke i.e., patients who have had previous stroke six weeks or less have greater chances of improvement and get back to their normal life as compared to the chronic stroke i.e., stroke patients who had stroke attack six months or more. Unlike acute stroke patients, chronic stroke patients have the habit of compensating with non-paralyzed upper and lower extremities in performing activities of daily living. Therefore, improving the functions of the upper limbs on the paralyzed side does not affect their daily activities much.

Although the EMG based therapy have significant effects on stroke patients however, there are some limitations to this therapy. First, this study is only useful for acute stroke patients but no for chronic stroke patients, therefore there is a need of assessment of duration of therapy and type of EMG channels for having useful effects on chronic patients. Second, because of the small number of subjects, the results of this study may not be generalizable to all stroke patients.

In the present study, the aim of using the four channel EMG system was to generate the neuromuscular stimulation which induce gripe release or finger extension and shoulder-elbow function with selective training of movements and daily living activities. It may also improve selective recovery of motion in post-stroke arm paralysis. Several authors describe a better outcome in multichannel EMG than in classical single-channel electrical stimulation or voluntary movement in patients. In previous studies, a daily treatment duration of 45-60 minutes has been described as necessary to achieve some beneficial effects, but negative side effects such as muscle fatigue have been reported later due to which the therapy duration has been reduced to 20-25 minutes for each exercise regimen. In this preliminary trial, it could also be demonstrated that four channel EMG system stimulation with a real intervention time of 23.5 min was well tolerated and well-integrated by the study participants.

There have been seen improvement in Fugl Meyer assessment test. The scores of all the patients improved except Patient D who already had low score before therapy. The maximum improvement in score in Fugl Meyer assessment test after therapy was observed in patient A & E with 5 scores increase in each patient.

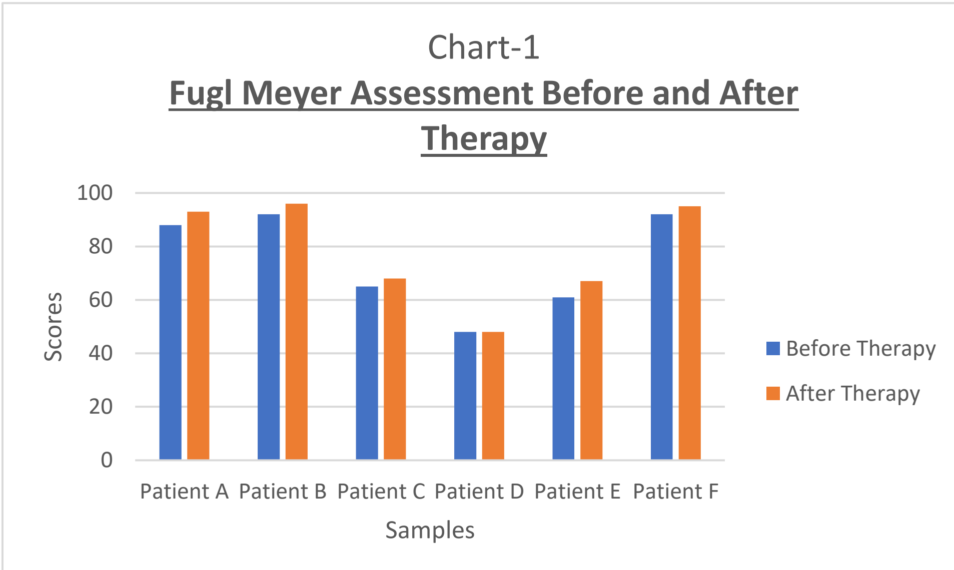

Figure 3 Fugl Meyer Assessment Before and After Therapy

In Action Research Arm Test, all the patients show improvement in scores. However, slight improvement has been observed in patient F and D with increase of 0.5 and 1 score respectively. The maximum improvement in score has been observed in patient E followed by patient A with increase in score of 5 and 4 respectively.

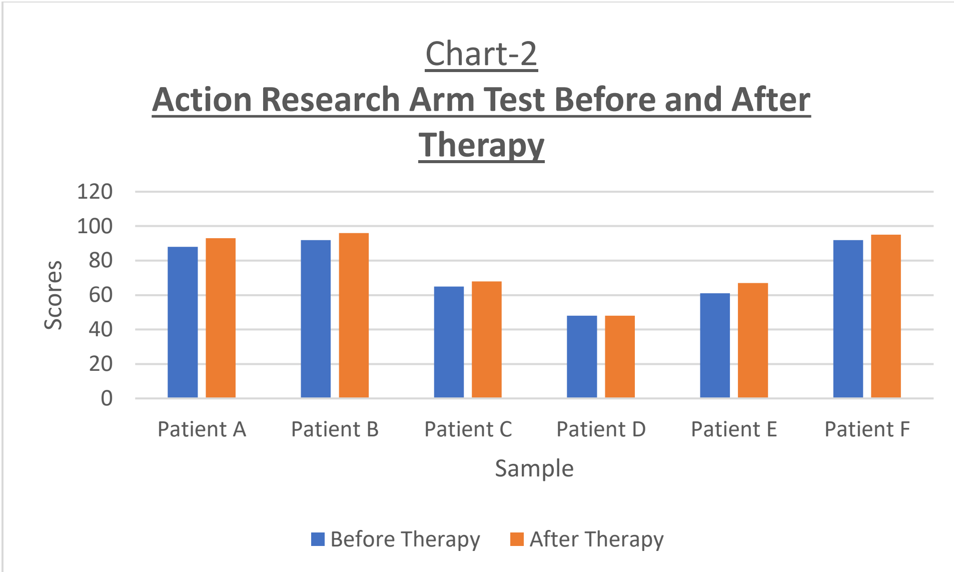

Figure 4 Action Research Arm Test Before and After Therapy

In block and box test, the score of patient A before and after therapy remains the same. All the other patients show improvement in their scores. The maximum improvement has been observed in patient E with 12 score increase followed by patient C with 7 score increase. Remaining patients showed slight improvement in scores.

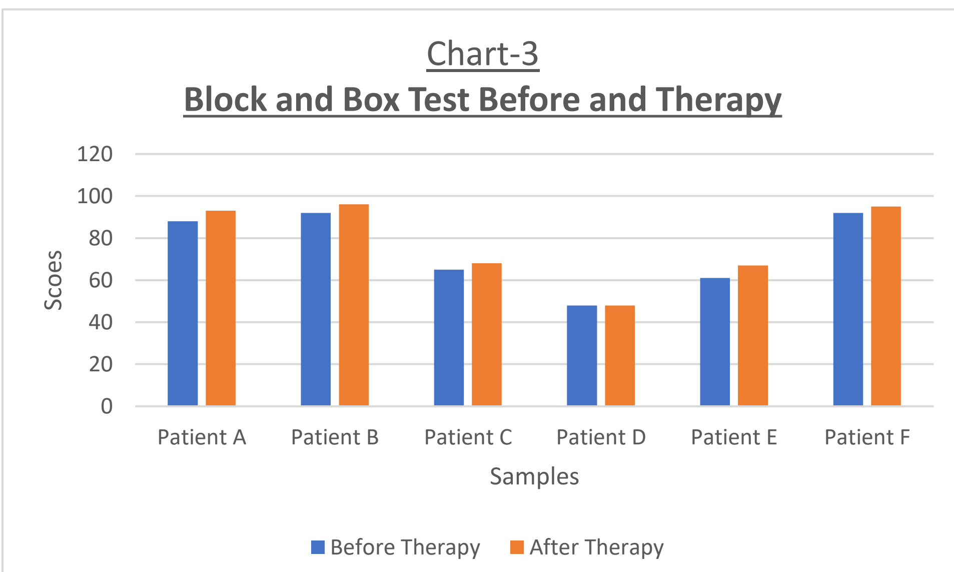

Figure 5 Block and Box Test Before and Therapy

In 9-peg hole test, all patients show improvement in their score. The highest improvement in score has been observed in patient F with 3 scores improvement followed by patient A and D where improvement of 2 points in both has been observed. The remaining patients showed the improved of only 1 score.

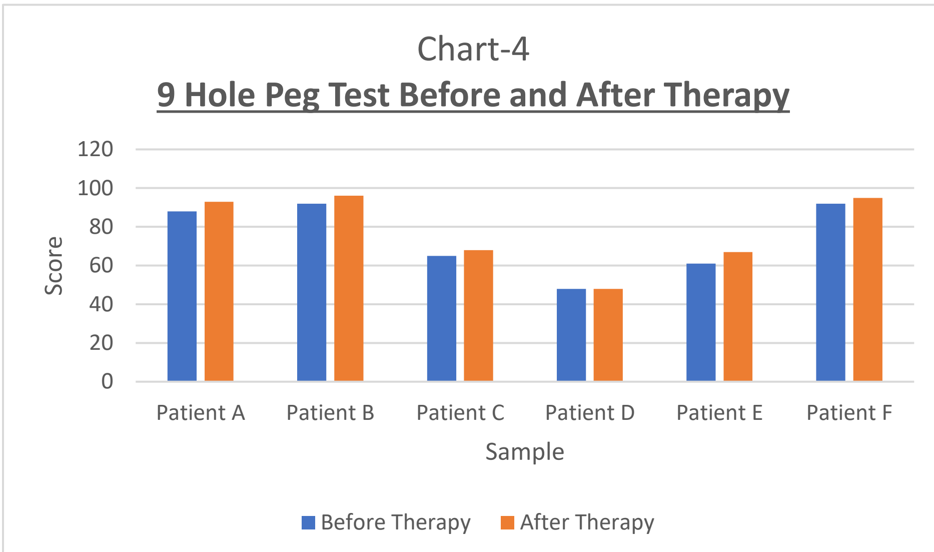

Figure 6 9 Hole Peg Test Before and After Therapy

In this present study, patient E has shown the increased collective score of 24 in all the assessment test before and after therapy followed by patient C with 16 scores, patient A with 11 scores, patient B with 10 scores, patient F with 9 scores and the least improvement in overall score has been observed in patient D with just increase of 5 scores. The least improvement in patient D is most probably due to the severe stroke in higher age which has severe affects in performing ADLs. Whereas, the patient E has been observed to be more vigilant in taking part to these activities and hence showed maximum improvement. All the other patients also showed improvement in their scores that suggested that if the continuous therapy has been provided to these patients, they can perform even better and can be returned back to their normal life. This EMG based therapy can easily be done at home without any specialized supervision. However, it is suggested that the duration of the therapy per day should be maintained carefully as the electrical stimulation for large duration of time can cause fatigue in the muscles. As per this study, the duration of 20-25 minutes is ideal for providing EMG therapy daily, continuously to get the maximum results.

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