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Original Research Article

Effect of Electromyographic Feedback in Improving Strength of Lower Limb Muscles in Chronic Ischemic Stroke Participants: An Interventional Study

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ABSTRACT

Background and purpose: Stroke is the common neurological disorder after age of 40, clinically described by spasticity, weakness, functional limitation, balance impairment and other neurological impairments.EMG feedback is the strategy by which electrical signals of muscles transfer into visual and auditory forms to make the patient aware of the condition. EMG feedback is the classical conditioning therapeutic intervention in Stroke rehabilitation.
Purpose of this study was to find the effectiveness of EMG feedback with conventional physiotherapy in improving the strength of lower limb muscles in chronic ischemic stroke subjects.
Materials and methods: 30 subjects of chronic stroke who match the inclusion criteria for this study were assigned into two groups of 15 patients each group. Group A was treated by conventional physical therapy and Group B was treated by EMG feedback with conventional physical therapy. Outcome measures were taken prior to the intervention and at the end of 12th week of post intervention. The outcome measures for strength by HHD, ROM by Goniometry, and TUG for functional mobility.
Results: The participants treated with EMG feedback with conventional physiotherapy shown greater improvement in Strength (p=0.01 for knee flexors, 0.02 for knee extensors, <0.001 for dorsi flexors and <0.001 for planter flexors) ROM (p=0.01for knee ROM, 0.01for dorsiflexion and 0.02 for planter flexion) and TUG (p=0.02) than participants treated with conventional physiotherapy alone.
Conclusion: EMG feedback is more effective measure when combined with conventional physiotherapy than conventional physiotherapy alone in improving strength of lower limb muscles in chronic ischemic stroke subjects.
Key words: Stroke, EMG feedback, Conventional physiotherapy, HHD, ROM, TUG

INTRODUCTION

Stroke is the major consequence of cerebrovascular accident has been shown to be a major cause of death and disability in all societies. [1] Cerebrovascular accident ranked as the second leading cause of death after ischemic heart disease. Stroke patients are at risk of death in the first weeks after the event, and between 20% to 50% die within the first month depending on type, severity, age, co morbidity and effectiveness of treatment complications. [2]

Stroke is defined as "Rapidly developing clinical signs of focal or global disturbance of cerebral function, with symptoms lasting 24 hours or longer or leading to death, with no apparent cause other than of vascular origin" [2] Stroke is a major health problem, which can results into disabilities on a physical, cognitive, social and communicative level. Stroke prevalence among the elderly in rural India was 1.1% and urban India was 1.9%. Prevalence is directly proportional to age and inversely proportional to the education levels of stroke survivors. [3] The morbidity of stroke in India was 400-800 per 100,000 in 2005. [4] Risk factors for stroke are hypertension, cardiovascular disease, age, obesity, diabetes mellitus and abnormal cholesterol and lipid profile, hyperuricemia and genetic or familial. [1]

Ischemic stroke is the most common form of stroke, which accounts approximately 80% of all strokes. Hemorrhagic stroke accounts for 15% to 20% of all strokes. [2] Anterior Cerebral Artery (ACA) is the first and smaller of two terminal branches of internal carotid artery. The interruption of blood supply to ACA can lead to ACA syndrome. The most common characteristic of ACA syndrome is contralateral hemiparesis and sensory loss with greater involvement of lower extremity because the somatotopic organization of the medial aspect of cortex includes the functional area for the lower extremity. Primary impairments are muscle weakness, tone alteration, abnormal synergy patterns, abnormal reflexes and sensory loss. [4]

Weakness of muscles is found in 80 to 90 percent of all patients after stroke and is a major factor in disability. [5] Patients are unable to generate the muscular force necessary for initiating and controlling movement. Patients deficit on the contralateral side include hemiparesis (opposite UE and LE). Typically, distal muscles exhibit greater strength deficits than proximal. [6,7] This can be explained by the greater facilitation of distal muscles than proximal by corticospinal system. [4] The causes of leg predominant weakness can be due to many reasons. The lesion situated area can affect the predominance of weakness. The sites of lesion may be of ACA territory, MCA territory, internal capsule, Brainstem and Thalamus. Medial part of the premotor gyrus lesion can cause contralateral predominant distal leg weakness. [8]

Observed muscle weakness is also associated with a number of changes in both the muscle and the motor unit. Changes occur in muscle composition, including atrophy of muscle fibers. There is a selective loss of type II fast twitch fibers with an increase in the percentage of type I fibers in muscles. [9] This selective loss of type II fibers results in difficulty with initiation and production of rapid high-force movements. The number of functioning motor units and discharge firing rates of motor units decrease as much as 50 percentages at 6 months after occurrence of stroke. [10] This is explained by the presence of transsynaptic degeneration of alpha motor neurons that occurs with loss of corticospinal innervations. So, after stroke strength is impaired bilaterally but more so at the contralateral side to the brain lesion. [11] This observed muscle weakness can affect the gait speed, gait endurance and functional balance.

Feedback is ‘a method of controlling the system by re-inserting into it the results of its past performance.’ [12] The principle of feedback is patient’s motor behavior or physiological change can be detected by measuring device or feedback device following changes are displayed (audible or visual) by an indicator. This information is perceived and develops understanding towards the changes and patient has conscious control over the motor behavior and the process continues. The mechanism of EMG feedback to improve motor response is done by operant (behavioral) conditioning which leads to neural plasticity and improve functional level in neuromuscular rehabilitation. [12,13]

Operant conditioning occurred in the form of positive rewards to the patients during their feedback session. Auditory, visual reward by EMG feedback instrument and verbal rewards from therapist can improve the performance of the patient. Particular movement is rewarded to perform isolated movement and muscle work. These rewards can make the patient to do isolated movement to occur repetitively. This can improve strength of isolated muscle groups. [14,15] EMG feedback is the use of electronic instrumentation to detect and feedback the myoelectric signals from skeletal muscles in order to allow the patient to gain better volitional control over the muscle. [14] EMG as a diagnostic purpose was first used by Du Bois-Reymond by describing the muscle membrane potential and subsequently the first to detect the electrical manifestations of voluntary muscle contraction in man. [6] As early as 1830 EMG recordings were made from animal preparations and at the late 1960s Andrews, Mims and Marinacci and Horande addressed the potential use of EMG with hemiplegic patient for biofeedback. [16]

The principle of EMG Feedback is based on converting myoelectrical signals sensed from muscles by surface electrodes to auditory and/or visual signals. [16] Using EMG monitoring, a visual or auditory signal is provided to the patient when a preset threshold of muscle activity is achieved. The threshold limits can be modified as the patient progresses. [17] EMG feedback is used in many clinical conditions and has gained a firm place particularly in retraining muscles.16 EMG feedback can be used as either to reduce or enhance muscle activity. [18] To participate in EMG feedback training, the patient must have sufficient vision to see the visual display, audition and reception to hear and comprehend simple directions, and expressive abilities and motor planning skills to respond to basic instructions. [18]

Feedback may be useful for reeducation of the muscles, through the use of positive "rewards," feedback encourages increased muscular contraction, which is beneficial during strength training. It can also promote the improved timing of muscle activation, which in turn benefits dynamic stabilization, [17] and allows a participant to monitor a voluntary contraction. [19] Aiello E et al concluded in their study 'Visual EMG Biofeedback to Improve Ankle Function in Hemi paretic Gait' that Subjects showed an increase in gait speed, time of single leg support on the affected side, ankle power generation at push-off and a reduction in knee extensor moment. These results indicate that treadmill gait retraining augmented via visual EMG-biofeedback facilitates improvements in hemi paretic gait. [20] Subjects showed an increase in gait speed, time of single leg support on the affected side, ankle power generation at push-off and a reduction in knee extensor moment. [20]

Conventional Physiotherapy is Physiotherapeutic measures used as an important tool to improve strength and function of lower limb following stroke. [9] Progressive Resisted Exercises (PRE) are given as a conventional Physical Therapy measure to improve strength following stroke. Many studies suggested that PRE improve strength and functional position after stroke. Weisstel. et al. 2000 evaluated that following PRE there are 68% strength gain in paretic lower limb in hip flexors, extensors, abductors and knee extensors. [9] Richard W. Bohannon systemically evaluated 'Muscle Strength and Muscle Training after Stroke'. He said that progressive resisted exercises can improve strength of lower limb muscles which can improve gait speed and independence in patients with stroke. It has been shown to improve functional activity by progressive resisted exercise training. [21]

Son SM et al conducted a study on 'Influence of Resistance Exercise Training to Strengthen Muscles across Multiple Joints of the Lower Limbs on Dynamic Balance Functions of Stroke Patients'. They evaluated the effects of resistance exercise training for strengthening muscles across multiple joints on the dynamic balance function of stroke patients. The training group additionally performed three sets (eight to 10 repetitions per set) of resistance exercise at 70% of the 1-repetition maximum (1RM) to strengthen muscles across multiple joints. They concluded that

Training involving muscle strength across multiple joints is an effective intervention for improvement of dynamic balance function of stroke patients. [22]

From these evidences this study intends to analyze the effectiveness of EMG feedback along with conventional physical therapy in improving the lower limb muscle strength in participants with chronic ischemic stroke.

NEED AND SIGNIFICANCE OF THE STUDY

It is showed that EMG feedback facilitates neuromuscular re education by providing essential information to the brain since the brain has lost the ability of acquiring that information on its own. EMG feedback provides best executed muscle function to the patient to relearn the lost function in extremity.

Thus this operant learning mechanism provides improvement in neuromuscular function. Thus need of this study is to find the effectiveness of EMG feedback in strength and lower limb functions following chronic stroke participants that can be useful for clinical purposes for patients with chronic stroke.

MATERIALS AND METHODOLOGY

Research Design: Interventional study

Sample Design: Convenience Sampling followed by systematic allocation (ODD: EVEN)

Study Population: Chronic ischemic stroke participants in Surendranagar

Sample Size: 30 Group A: 15 participants
Group B: 15 participants

Study Setting: Physiotherapy Outpatient Department

Study duration: 10 months (January-2014 to October-2014)

Treatment duration: 12 weeks

Ethical approval: Obtained from Institutional Ethical Committee

Selection criteria:

Inclusion criteria:

1. A history of first time stroke (6 months or more post CVA)
2. Participants with ischemic stroke
3. Patients willing to participate in this study
4. Age 45-65 yrs
5. Patients who can voluntarily activate lower limb muscles (ankle dorsiflexors, knee flexors, knee extensors)
6. Voluntary control grades of 3-5 in Brunnstrom grades
7. With spasticity at 1 or 1+ grades in Modified As worth Scale
8. Both genders are included

Exclusion criteria:

1. Patients who have More than one stroke incident
2. Other severe medical conditions in combination with stroke (Arterial and venous insufficiency)
3. Stroke participants with lower limb musculoskeletal disorders
4. Prior surgery to hip, knee or ankle
5. Patients with auditory, visual impairment and perceptual impairment

Sampling technique:

From the 47 participants, 30 participants fulfilling the inclusion criteria were selected. The purpose and procedure of the study were explained to the participants and signed consent form was obtained from them. Prior to the study all participants were examined neurologically and the participants' demographic data were noted. Screenings of all participants were done by Brunnstrom grades for Stroke. According to convenient sampling method with systemic allocation, participants were allocated into 2 groups; Group A and B with 15 participants in each group.

Outcome measures:

- **Primary Outcome Measures:**

1. Hand Held Dynamometer (HHD)

- It is a quantitative measurement of strength for limb muscles. A interval value can be obtained from measurement.
- It is a reliable and valid (0.57-0.86) measurement for strength measurement stroke [23]

- **Secondary Outcome Measures:**

1. Timed Up and Go test (TUG)

- The TUG is used to measure mobility, balance, walking ability and fall risk in older adults.

- It is valid and reliable measurement of functional mobility in the subjects of stroke (ICC>0.95). [24]

2. Range Of Motion at Ankle and Knee joint

- Goniometry is the classical method to measure the ROM. The full circle or half circle goniometer is mostly used equipment to measure ROM in all four limbs and spine.
- It is a valid (0.58) and reliable method to measure ROM in extremities and spine. [25]

Data collection procedure:

After the ethical approval obtained from the ethical committee of the institution, participants who fulfilled the inclusion criteria were evaluated clinically. The purpose and procedure of this study was explained to the participants and asked to sign the consent form. After collecting consent form from the participants, the data were collected for the strength of lower limb through HHD and functional mobility measures through TUG and ROM of lower limb through goniometry, than the participants were randomly divided into two groups(A and B). Group A had been given conventional strengthening exercises to the lower limb muscles (knee flexors, knee extensors, ankle dorsi flexors and ankle planter flexors) and Group B been given EMG feedback and conventional strengthening exercises. Total duration of treatment is 12 weeks (2days/week) for both the groups.

Treatment procedure:

Group A – conventional physiotherapy

- Stretching exercises for upper limb and lower limb muscles
- Strengthening exercises for upper limb
- Strengthening exercises for lower limb (12-wk 2×per week at 70% of 1 RM for lower limb muscles (Knee flexors, knee extensors, ankle dorsi flexors and ankle planter flexors). [9]
- General mobility exercises for upper limb, lower limb and trunk
- Balance exercises and gait training.

Group B – conventional physiotherapy (as mentioned in Group A) with EMG Feedback treatment for lower limb muscles (knee flexors, knee extensors, ankle dorsi flexors and ankle planter flexors)

Parameters for EMG feedback.

- Noise level: 500µV
- On: Off phase: 10:10 sec
- Input Impedance: >1,000,000ohm
- Input Sensitivity: <1.0µV RMS
- Frequency Range: 15 Hz-300Hz with CMMR of >120dB at 50/60Hz >180dB

For treatment electrodes were placed over the belly of the muscle group and ground electrode placed in between active and reference electrode and EMG activity was determined. This treatment of EMG feedback was given to the knee extensors, knee flexors, and ankle dorsiflexors at affected side for 2 times a week for 12 weeks for 30 minutes per session.

EMG feedback was provided by visual feedback by increment in graphical representation at the screen of the equipment and audible feedback was provided at targeted amplitude

RESULTS

Baseline data was taken for Age and Gender. Baseline data has been shown in following table.

Mean Age of Participants

	MEAN
Group A	55.6
Group B	55.06

GENDER DISTRIBUTION	
Male	18
Female	12

Data were obtained before intervention and after 12 weeks of intervention for all the participants in both the groups.

HHD strength was taken for knee flexors, knee extensors, ankle dorsiflexors and ankle planter flexors for affected side. ROM measurement was taken for knee joint, ankle dorsiflexion and ankle planter flexion on affected side of the participants. TUG test was performed for all the participants before the intervention and after 12 weeks of intervention.

Paired t-test was done for the comparison between the pre and post values of outcome measures within both the groups.

Unpaired t-test was done for the comparison between the post-post values of outcome measures between the groups.

The statistical significant level adopted for the statistical tests was 5%.

Following are the tabular representation for each outcome.

Strength of Knee Flexors

GROUP	PRE		POST		INTRAGROUP	
	MEAN	SD	MEAN	SD	tvalue	pvalue
A	4.03	1.12	4.40	1.02	2.3	0.02
B	3.83	0.93	5.53	1.20	5.1	<0.001
INTERGROUP					2.91	0.01

Strength of Knee Extensors

GROUP	PRE		POST		INTRAGROUP	
	MEAN	SD	MEAN	SD	tvalue	pvalue
A	6.26	1.57	7.03	1.54	2.1	0.05
B	3.76	1.47	8.16	1.57	3.7	0.01
INTERGROUP					2.59	0.02

Strength of Ankle Dorsiflexors

GROUP	PRE		POST		INTRAGROUP	
	MEAN	SD	MEAN	SD	tvalue	pvalue
A	2.06	0.88	2.73	0.37	2.81	0.02
B	2.36	0.26	6.13	0.63	5.2	<0.001
INTERGROUP					5.03	<0.001

Strength of Ankle Planter Flexors

GROUP	PRE		POST		INTRAGROUP	
	MEAN	SD	MEAN	SD	tvalue	pvalue
A	3.03	1.20	3.8	0.84	2.46	0.02
B	3.4	1.33	4.7	1.14	3.45	0.01
INTERGROUP					5.21	<0.001

Knee Rom

GROUP	PRE		POST		INTRAGROUP	
	MEAN	SD	MEAN	SD	tvalue	pvalue
A	69	19.65	70.66	19.08	2.5	0.02
B	67.66	20.60	91.66	15.54	4.88	<0.001
INTERGROUP					3.3	0.01

Ankle Dorsiflexion Rom

GROUP	PRE		POST		INTRAGROUP	
	MEAN	SD	MEAN	SD	tvalue	pvalue
A	6.13	1.64	9.40	2.06	2.4	0.02
B	6.06	1.83	11.86	4.08	5.8	<0.001
INTERGROUP					3.55	0.01

Ankle Planter Flexion Rom

GROUP	PRE		POST		INTRAGROUP	
	MEAN	SD	MEAN	SD	tvalue	pvalue
A	18.4	3.85	19.6	2.92	2.2	0.05
B	17.26	3.82	21.26	2.93	4.5	<0.001
INTERGROUP					2.12	0.02

Timed Up and Go Test

GROUP	PRE		POST		INTRAGROUP	
	MEAN	SD	MEAN	SD	tvalue	pvalue
A	27.53	2.79	26.40	3.04	4.05	0.01
B	27.06	3.41	24.40	2.74	8.44	<0.001
INTERGROUP					9.77	<0.001

DISCUSSION

The purpose of the study was to assess the effectiveness of Electromyographic feedback to improve strength of lower limb muscles in chronic ischemic stroke patients. 24 sessions of electromyographic feedback along with conventional therapy was given for 30 minutes to the patients in Group B. While conventional therapy alone was given to patients in Group A. The primary outcome measure was HHD to measure strength. Secondary outcome measures were ROM and TUG test.

In this study there were improvement in strength, ROM and function, static and dynamic balance seen for all the patients of both the groups A and B. Intra group analysis for Group A in strength measurement showed significant improvement. For knee flexors (p=0.02), knee extensors (p=0.05), dorsiflexors (p=0.02) and Planter flexors (p=0.02). There was significant improvement seen in group B also. Intragroup analysis of Group B showed significant difference for knee flexors (p=<0.001), knee extensors (p=0.01), dorsiflexors (p=<0.001) and planter flexors (p=0.01).

To measure the improvement in ROM, Goniometry measurement was taken for both the groups. After assessing, intra group analysis was done using paired t-test for both the groups. This analysis for Group A showed significant improvement for knee ROM (flexion and extension) (p=0.02), dorsiflexion (p=0.02), planter flexion (p=0.05). Intragroup analysis of Group B showed significant improvement to improve ROM for knee ROM (flexion and extension) (p=<0.001), dorsiflexion (p=<0.001) and planter flexion (p=<0.001).

For functional measurement Timed Up and Go (TUG) test was performed at 1st day and at the end of 12 weeks. Intra group analysis for TUG in group A showed significant improvement (p=0.01) and for group B it showed significant improvement. (p=<0.001).

To assess the comparison between two groups Independent t-test was used. Independent t-test for strength showed significant improvement for Group B. For knee flexors (p=0.01), knee extensors (p=0.02), dorsi flexors (p=<0.001) and planter flexors (p=<0.001). This result shows that Group B shows significant improvement in strength.

Independent t-test was done for ROM of knee and ankle joints. Intergroup comparison for ROM showed improvement in knee ROM (p=0.01), dorsiflexion (p=0.01) and planter flexion (p=0.02). For TUG independent t-test was done which showed significant improvement in Group B (<0.001).

Stroke is the most commonly seen after UMN lesion. Primary impairments of Stroke are spasticity, weakness, poor balance and functional difficulties. Weakness is the most challenging impairment to treat and to gain the strength in chronic stage of Stroke.

After UMN lesion, there is a reduction in the number of functioning motor units of the muscle. After 4 months of cortical lesion there are markedly reduced motor units up to half. On the basis of axonal stimulation and motor unit recording, motor neurones maintained their functional properties for the first two months after a cortical lesion. At some time within the next four months the number of functioning motoneurones was reduced to approximately half.

The statistical foundation for the importance of muscle strength after stroke is based on research showing that muscle strength is related to functional activity performance. The strength of multiple muscle groups of both the paretic and non-paretic lower limbs has been shown to correlate with independence in the stand-pivot-sit transfer. After UMN lesion there is selective loss of type-2 fibers in the muscles which can be contribute for muscle weakness in patients with Stroke.

There are different modalities available to improve strength in hemiplegia/hemiparesis. Conventional strengthening exercises are most commonly used among them. Other method to improve strength is Electromyographic feedback.

The principle of EMG BF is based on converting myoelectrical signals sensed from muscles by surface electrodes to auditory and/or visual signals. Surface EMG can not measure muscle contraction directly and cannot give results in units of force but it measures an electrical correlate of muscle contraction and gives the results in terms of electrical units (volts). So we can say that the EMG BF device is a voltmeter. Monitored electrical activity of the muscle is often referred to as "raw EMG". Raw EMG is a blasting sound that rises and falls in loudness in relation to muscle contraction.

Many forms of auditory tones are available and these can be continuous or pulsed. The forms of the tones are chosen according to the application requirements and propensity. Among various auditory signals there are clicks, tones or beeps. The device can be set up according to the clinical condition and the decision of the clinician. For example it is set up to produce a beep when a patient contracts a muscle and the EMG level is higher, and during relaxation the device emits no sound. In this way the patient is encouraged to work harder to get another beep if strengthening of a muscle needed in the rehabilitation program. With the same device another option can be arranged; as the patient relaxes and the EMG activity decreases, a click occurs.

To apply Electromyographic feedback patient must have control in the muscles. Patient should isometrically contract the particular muscle for 6-10 seconds. There should not be any visual and auditory impairment to the patient for audio-visual feedback.

Mechanism to improve muscle strength after application of Electromyographic feedback is based on learning theories. Operant conditioning is occurred following Electromyographic feedback. Visual and auditory feedback with positive verbal rewards can make the patient to improve muscle contraction.

During EMG feedback patients see the visual improvement in the Raw EMG with different auditory feedback with improvement. This activity can be enhanced with verbal commands. These combined effects can encourage the patient to contract the muscle group more and more for further better feedback.

Colgan et al in 1980 had suggested that direct sensory information from the muscle is needed for control and without it, it seems unlikely that significant therapeutic benefits can occur. This confirms that with repetitive muscle performance with sensory information can improve muscle function. [26]

Due to motor learning there is brain reorganization occurs for neural function. Merzenith and colleagues have done studies on monkeys and suggested that the somatotopic maps in normal animals show extensive difference between individuals according to repetitive functions done by every individual. When a particular movement is induced or encouraged to do after CNS lesion, there is reorganization around the somatotopic area of that function. Somatotopic area of that function becomes larger than normal.

Green JB. In 2003 studied on Brain reorganization after stroke. Author said that After a stroke, recovery that continues beyond 3 or 4 weeks has been attributed to plasticity, a reorganization of the brain in which functions previously performed by the ischemic area are assumed by other ipsilateral or contralateral brain areas. This brain reorganization can improve particular function of the patient after Stroke. [27]

In this study after application of EMG feedback to lower limb muscles, repetitive movements of lower limb joint occur and that can lead to brain reorganization following stroke to the patient and that can lead to improve strength, ROM and functional mobility after treatment of EMG feedback with conventional therapy.

Dynamical action theory introduced different attractor states to improve function. These attractor states may be considered preferred patterns of movement used to accomplish common activities of daily life. There are three attractor states according to the difficulties of activities. Thelen in 1989 explained these attractor states by how a marble moves on different surfaces. Shallow well explain optimal movement patterns for daily life and modifications in the task while deep well illustrate a rigid pattern of movement for doing many task in daily life. There is no modification in the task. [28]

In acute stage of stroke patients seem to come under the deep well attractor state. As the recovery occurs patients may come under the shallow well attractor state.

By EMG feedback, it improves the functional ability, balance of the patients of stroke. This can improve the patient's condition and make him/her to come under the shallow well attractor state instead of deep well attractor state which makes the patient restricted to ADLs. [29]

Task oriented EMG feedback can improve functional activity of CNS. According to Dynamical Systems theory, there is heterarchical model of nervous system. They explained that higher centers interact with the lower centers but do not control them. Closed loop and Open loop systems cooperatively and both feedback and feed forward control are used to achieve a goal/task. This systems theory can explain the feedback mechanism to improve the functions of the patients of stroke.

Neural adaptation is the foundation of learning. The potential for neural change has been most extensively studied in the young of various species, specifically during development. However, it is now clear that changes in the structure and function of the nervous system can occur across the life span through engaging in highly attended, repetitive, and rewarded behaviors.

In order to maximize neural adaptation, behaviors which drive changes in the nervous system require attention, repetition over time, and positive feedback. The behaviors should be goal directed and interesting to facilitate motivation and commitment. The learned behaviors must be repetitive, but not stereotypical. It is known that motor imagery recruits a measurable neuronal response. Thus, repeated implicit or explicit imagery also can be associated with learning.

There is Regenerative Synaptogenesis occur for injury induced recovery of function. Axonal sprouting occurs after injury when brain is repetitively stimulated for functional activity and task. Bjorklund had done research first time and provided evidence on neural growth and regeneration were possible. This regenerative Synaptogenesis around injured brain tissue can improve the function of that area injured. [30]

There are collateral sprouting or reactive sprouting occur following brain injury when neighboring normal axons sprout to innervate synaptic sites which were previously activated by injured axons. Axons that begin to sprout belong to the same neural system that originally innervated the synaptic sites. There are evidences that sprouting of the axons occur in the opposite side of the brain at the same neuronal site also. [15]

Following these theories there is reduction in spasticity which decreases the activity of γ-motor fibers and increases the activity of α-motor fibers. This facilitation of α-motor fibers and reduce spasticity. Reduction in spasticity will improve the muscle performance.

In the stroke patients, they have brain injuries at different levels. The implication of these theories can be done to improve strength, ROM and function of the patients. Improvement of the patients of stroke following the treatment of EMG feedback and conventional physical therapy, we can suggest that the measured improvements in strength the EMG feedback may be due to the underlying concepts of motor learning, brain reorganization, neural plasticity and dynamic systems theory.

CONCLUSION

Electromyographic feedback is more effective when combined with conventional physiotherapy than conventional physiotherapy alone in improving strength of lower limb muscles in chronic ischemic stroke participants

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