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Original Article

EFFECT OF AUDITORY & VISUAL BIOFEEDBACK WITH ELECTRICAL STIMULATION OF THE TIBIALIS ANTERIOR MUSCLE ON ACTIVE ROM & SELECTIVE MOTOR CONTROL OF ANKLE OF CHILDREN WITH SPASTIC CEREBRAL PALSY

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ABSTRACT

Background & Objective: Cerebral palsy (CP) is the most common cause of movement disability in childhood, with an incidence of 1.5–2.5 per 1000 live born children. It is a non-progressive disorder that covers a number of neurological conditions, resulting in an abnormal development of movement and postural control**.** It is believed that an inability to maximally activate their muscles contributed to this weakness. Visual and auditory feedback cues have been shown to improve ROM & VMC in patients with movement disorders. The aim of this work was to investigate the efficacy of using biofeedback and neuromuscular electrical stimulation applied on tibialis anterior in children with cerebral palsy. The present work was designed to compare the effect of treatment with or without biofeedback applied to children with diplegic CP.

Materials and Method: 30 children with CP were divided in to 2 groups (experimental & control). Control group received NMES on tibialis anterior for 20 min. a day, 6 days in a week for a period of 6 weeks, experimental group received NMES + biofeedback + conventional treatment. Pre and Post treatment evaluation included range of motion ,VMC and GMFM scoring.

Results: Results showed that there was main effect for time and there are main effects were qualified by a group × time interaction. There was main effect for time, $f(1,28;0.05)=4.64$, $p<0.04$ & a main effect for group, $f(1,28;0.05)=485.96$, $p<0.00$,however there main effects were qualified by a group × time interaction, $f(1,28;0.05)=65.96$, $p<0.00$ in right and left ankle joint.

Conclusion: A significant improvement in range of motion, VMC & GMFM in experimental group as compare to control group. The study determined that biofeedback have positive clinical effects on the ROM & VMC of ankle of spastic diplegic.

KEY WORDS: Range of Motion, Cerebral Palsy, Biofeed Back, Electrical Stimulation, NMES, Motor Control.

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INTRODUCTION

Cerebral palsy (CP) is the most common cause of movement disability in childhood, with an incidence of 1.5–2.5 per 1000 live born children [1]. It is a non-progressive disorder that covers a number of neurological conditions, resulting in an abnormal development of movement and postural control [2]. Cerebral palsy (CP) was first described by William little, an English physician in 1960's. CP was affectionately called "Little's Disease". Cerebral palsy (CP) is an umbrella term encompassing a group of non-progressive non-contagious motor conditions that cause physical disability in human development, chiefly in the various areas of body movement [3].

Muscle weakness has been reported to be a common symptom in children with cerebral palsy. It affects some muscles more than others, often showing greater involvement of the distal plantar flexors (PF) and dorsiflexors. Weakness, as defined by Edwards (1978), implies a failure or inability to produce or maintain an anticipated level of force [4, 5].

Neuromuscular electrical stimulation over the agonist or antagonist muscles of spastic muscle is shown to reduce spasticity [6]. There is some evidence that electrical stimulation of the antagonist muscles can reduce spasticity immediately following treatment. It has also been claimed that spasticity reduction by this method is achieved without any muscle weakness. Biofeedback, a procedure whereby information about an aspect of body function is fed back by a visual or an auditory signal, is a noninvasive technique that has been implemented to increase strength and improve motor control in patients with cerebral palsy [7, 8].

Some authors have demonstrated that surface electromyographic biofeedback (EMG-BFB) results in progressive increases in voluntary control of movement and meaningful improvement in patient functional capacity [9,10,11].

Biofeedback, a procedure whereby information about an aspect of body function is fed back by a visual or an auditory signal, is a noninvasive technique that has been implemented to increase strength and improve motor control in patients with cerebral palsy. The local effects of such a technique have already been assessed in patients with various neurological problems. Significant increases in heel contact in children who exhibit equinus gait were induced.

METHODOLOGY

Spastic CP diplegics with age group 4-10 yrs from SVNIRTAR who fulfilled the criteria will be randomly taken for the study.30 children were enrolled, 15 for experimental group and 15 for control group. Children will be taken into this group for 6 weeks i.e. 5 days/week. 15 minutes of feedback via fabricated goniometer & electrical stimulation will be given to Tibialis anterior muscle for 20 min. per day.

Position: (for feedback via electrogoniometer)- High sitting position with hip & knee 90^0 flexed. (For electrical stimulation)- High sitting with back & foot supported. The stimulation was applied using surface electrodes adapted on the size of child's muscle belly, so only the tibialis anterior was stimulated and thus overflow was eliminated.

Equipment fabricated & Used:

Visual and Auditory biofeedback (Electrogoniometer) (Fig. 1)

Electrical Stimulator

Universal Goniometer

The device was designed and fabricated by us for the ANKLE joints

It comprised of:

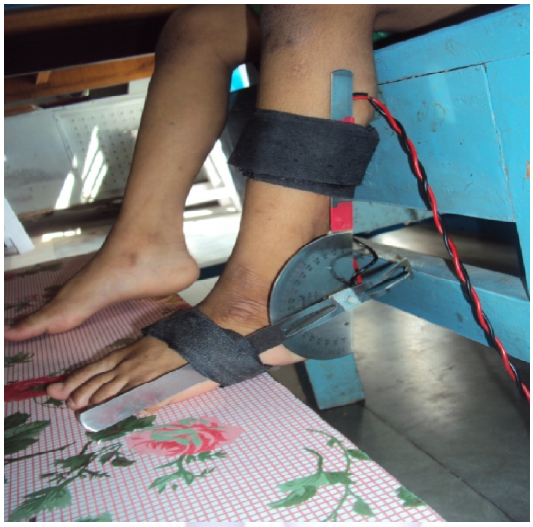
(a) Ankle unit.

Ankle unit comprised of a protractor with a stationary and movable arm.

(b) Audio - visual feedback unit.

Fig. 1: Showing Biofeedback Apparatus.

Fig. 2: Showing the placement of goniometer.

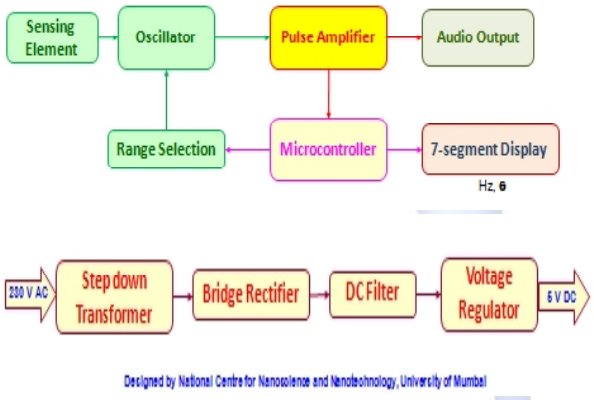


Audio- visual feedback unit comprised of fallowing:

Potentiometer: the shaft of which is rotated by the movable arm of the ANKLE unit, thereby changing the amount of resistance the potentiometer offers to electricity in the circuit, which in turn changes the frequency of the frequency generator, resulting in output which is through a speaker and LED bar.

Step- down transformer is used to step down the incoming 230V AC from mains to 12 volts and bridge rectifier circuit is used to convert the AC to DC.

Schematic Block Diagram for Angular motion measurement.



The monitoring of dorsiflexion is done on 6 digit 7-segment based display system.4MHz crystal oscillator along with IC for frequency scale down by factor of 2^{22} is used to get high precision 1Hz time base for our electronic logic circuit. Sensor for measuring the ankle movement is connected to the oscillator circuit, in which the change in frequency as well as duty cycle corresponds to the ankle ROM.

Data collection: Measurements of active ankle dorsiflexion range of motion, voluntary motor control of DF and gross motor function score were taken for each subject after completion of 6 weeks of therapy. The data collected were taken for analysis.

Data analysis: Data were analyzed using 2×2 ANOVA with one between factor (group) with two levels and one within factor (time) with two levels for range of motion of ankle joint. Between group differences for GMFM and VMC was done by Mann Whitney U test .An alpha level of 0.05 of significance was set.

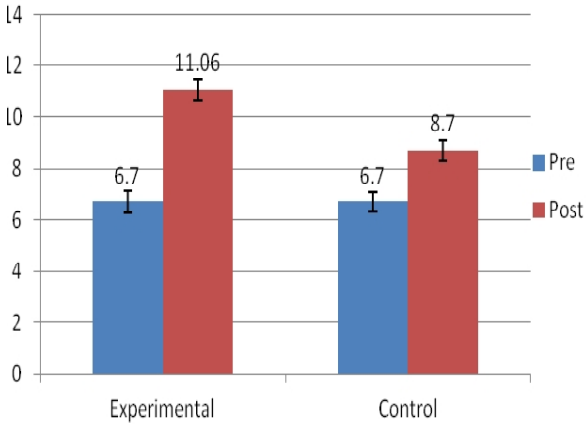
Analysis was performed using SPSS package 16 version.

RESULTS

Range of motion (left ankle joint): There was main effect for time, f(1,28;0.05)=4.64. p <0.04 & a main effect for group, f(1,28;0.05)=485.96, p<0.00, however there main effects were qualified by a group × time interaction, f (1,28;0.05)=65.96, p <0.00.

Post-hoc analysis showed that both the groups improved significantly however at the end of the treatment experimental group showed significantly more improvement.

Graph 1: Showing ROM Left side.

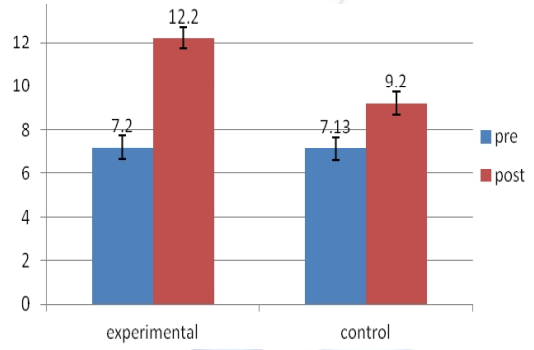


Range of motion (right ankle joint): There was main effect for time, f(1,28;0.05)=4.37.p <0.046 & a main effect for time, f(1,28;0.05)=1.30, p<0.00, however their main effects were qualified by a group × time interaction,

f(1,28;0.05)=219.37, p <0.00.

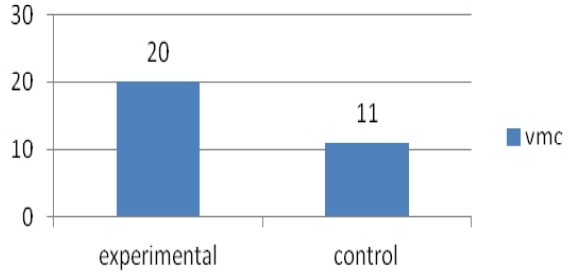
Post-hoc analysis showed that both the groups improved significantly however at the end of the treatment experimental group showed significantly more improvement.

Graph 2: Showing ROM Right side.



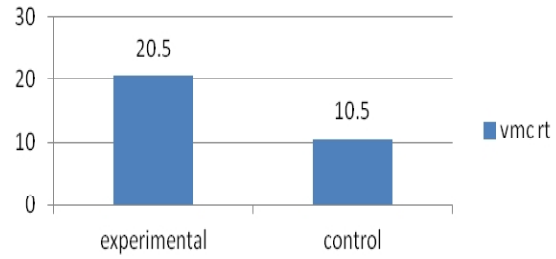
Voluntary motor control (left ankle joint): Graph 3 illustrates that there was significant improvement in voluntary motor control of left ankle dorsiflexion in the experimental group than the control group with the score of mann whitney U 45.00, Z score-3.52 & significance level of 0.004.

Graph 3: Showing VMC Left side.



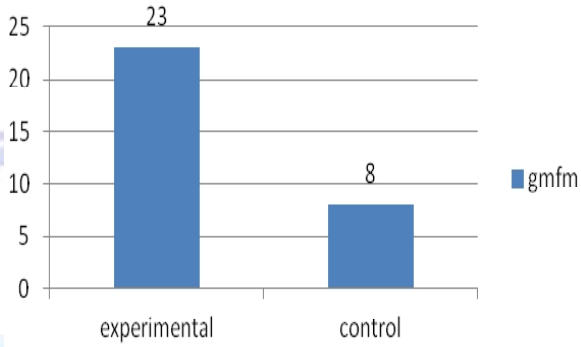
Voluntary motor control (right ankle joint): Graph 4 illustrates that there was significant improvement in voluntary motor control of right ankle dorsiflexion in the experimental group than the control group with the score of mann whitney U 37.00, Z score-3.59 & significance level of 0.001.

Graph 4: VMC Right Side.



Gross motor function (gmfm): Graph 5 demonstrates the subjects in the experimental group showed more significant change than control group in their gross motor function. Results of the study showing there is statistically significant difference in dimension D (standing) of the gross motor function measure between the experimental group with the significance level of 0.00,mann whitney U score –0.00 & Z score -4.73.

Graph 5: Showing gmfm.



DISCUSSION

Active ankle dorsiflexion range of motion: The present study shows that there was significant improvement in active range of motion with time in both the groups but the subject who had undergone biofeedback and NMES (experimental group) improved to a greater extent than the subject who received NMES and conventional exercises (control group).

There might be an improvement in antagonist muscle strength due to electrical stimulation which could help to overcome the spasticity of the agonist muscle. Increased dorsiflexion strength-with the application of biofeedback recruitment of higher number of motor units or higher firing frequencies can best explain the strength increase.

Voluntary motor control of ankle joint: There was increase in VMC of ankle joint found on the modified trust selective motor control test on both groups but the subjects who had undergone biofeedback and electrical stimulation improved to a greater extent than the subjects who received conventional therapy .

Repeated contraction of the dorsiflexors usingelectrical stimulation may cause planter

flexors to stretch slightly leading to stretch reflex inhibition and thus unmasking the voluntary movement.

Training with the use of feedback process is generally not a passive process, it requires the active participation of the patient by doing voluntary contraction & it causes recruitment of type 1 muscle fibers [12].

During voluntary contraction of muscle there is an asynchronous firing of motor neuron resulting in a smooth contraction as more motor units become involved, further increase in muscle force is largely achieved by increase rate of nerve impulse firing (milner-brown & stein, 1975) [4].

Theo mulder et al. reported in the improvement of voluntary control in hemiparetic patient with the use of EMG biofeedback.

Gross motor function: There was improvement of gross motor function in both the group, but the biofeedback and NMES group improved with a significant difference from the conventional group.

Subjects with cerebral palsy were examined using the gross motor function measure-66 (GMFM-66) the GMFM-66 is a test used for assessing motor function in children with cerebral palsy & it has been a useful measure to detect changes in motor function in intervention studies (Rusell et al. 1976). The GMFM-66 is chosen because it has been shown to be more reliable than the original test (now called the GMFM-88) as well as more sensitive to changes in function (Rusell.et al., wang & yang 2006. factors which were responsible for improvement in motor function included improved strength of pre tibialis. Dimension D of GMFM i.e. standing includes pulls to stand, maintain arms free standing for 3 sec, standing with one foot support, sit on a small bench etc. which requires proper body alignment and volitional control [13]. However it must be considered that there is always an impact of altered body mechanics on the performance of functional tasks. Achieving dosiflexion range in ankle or at least plantigrade position can influence the patient's ability to use his/her recovering control of volitional movement. (Barbara et.al. 2003)[14,15,16]

CONCLUSION

Over the years NMES is being used for improving the strength and function in case of upper motor neuron lesion. Recent advancement in clinical medicine and biomedical engineering also proved the implementation of biofeedback for improving range of motion and mobility function. Findings of the study shows that a combined programs of biofeedback, NMES for pre-tibialis & conventional therapy for 6 weeks durations improves the ankle ROM & VMC.

Study result also shows the significant improvements in gross motor function. The improvement confirms the therapeutic benefits of combined biofeedback & NMES regimen in CP.

Limitations: Smaller sample size, shorter duration and carryover effect of the combined regimen of biofeedback and NMES to pre-tibialis was not observed.

Abbreviations:

ROM- Range of Motion
NMES- Neuro Muscular Electrical Stimulation
CP- Cerebral Palsy
(EMG-BFB)- Electromyographic Biofeedback
VMC- Voluntary Motor Control
Gmfm- Gross motor function

Conflicts of interest: None

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